6. Materials Technologies

To strengthen national security, enable future economic growth, support energy dominance, and increase transportation energy affordability for Americans, the Vehicle Technologies Office (VTO) funds early-stage, high-risk research. The research will generate knowledge that industry can advance to deploy innovative energy technologies to support affordable, secure, reliable and efficient transportation systems across America. VTO leverages the unique capabilities and world-class expertise of the national laboratory system and works with partners across industry and academia to develop new innovations in electrification, including advanced battery technologies; advanced combustion engines and fuels, including co-optimized systems; advanced materials for lighter-weight vehicle structures and better powertrains; and energy efficient mobility technologies and systems, including connected and automated vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement. VTO is uniquely positioned to address early-stage challenges due to its strategic research partnerships with industry (e.g., the U.S. DRIVE and 21st Century Truck Partnerships) that leverage relevant technical and market expertise. These partnerships prevent duplication of effort, focus U.S. Department of Energy (DOE) research on the most critical research and development (R&D) barriers, and accelerate progress. VTO focuses on research that industry either does not have the technical capability to undertake on its own—usually because there is a high degree of scientific or technical uncertainty—or it is too far from market realization to merit sufficient industry emphasis and resources.

The Materials Technology subprogram supports vehicle lightweighting and improved propulsion (powertrain) efficiency through early-stage research & development (R&D) to discover and further understanding of how to manipulate and use novel materials and enabling technologies for industry to develop and deploy light- and heavy-duty vehicles. The Materials Technology research portfolio supports the Vehicle Technologies goals of affordable transportation and energy security. Reducing the weight of a conventional passenger car by 10% results in a 6%-8% improvement in fuel economy and similar benefits are achieved for battery electric and heavy-duty vehicles. To achieve this, research focuses on activities that have a high degree of scientific or technical uncertainty, or that are too far from market realization to merit sufficient industry emphasis and resources. The Materials Technology subprogram accomplishes its technical objectives through research programs with academia, national laboratories, and industry.

Lightweight Materials Technology supports research in advanced high-strength steels (AHSS), aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites (CFCs), and multi-material systems with potential performance and manufacturability characteristics that greatly exceed today’s technologies. 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- and heavy-duty vehicles. Propulsion Materials Technology supports research to develop higher performance materials that can withstand increasingly extreme environments and address the future properties of a variety of relevant, high-efficiency powertrain types, sizes, fueling concepts, and combustion modes.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2018 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied.

Question 1: Was the program area, including overall strategy, adequately covered?

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Question 3: Were important issues and challenges identified?

Question 4: Are plans identified for addressing issues and challenges?

Question 5: Was progress clearly benchmarked against the previous year?

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10: Has the program area engaged appropriate partners?

Question 11: Is the program area collaborating with them effectively?

Question 12: Are there any gaps in the portfolio for this technology area?

Question 13: Are there topics that are not being adequately addressed?

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Presentation Number: mat918
Presentation Title: Materials Technologies Overview
Principal Investigator: Felix Wu (U.S. Department of Energy)

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
This reviewer described the strategy as well-covered and defined for both Lightweight Materials and Power Train Materials.

Reviewer 2:
The reviewer replied positively; the strategy for both lightweight and propulsion materials were covered well, and quantitative targets and roadmaps were shown.

Reviewer 3:
This reviewer remarked that the presentation adequately covered DOE efforts in the area of materials.

Reviewer 4:
The reviewer asserted that the two goals of lightweighting the glider and improving powertrain materials were adequately described, but the strategy was modestly addressed. The presentation gave the roadmap, but not a strategy of how to move forward. This reviewer wanted to see more vision of where the work needs to be done.

Reviewer 5:
This reviewer stated no and recommended that future presentations focus on strategic direction versus historical accomplishments.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer stated yes; the balance was maintained very well. For example, some of the materials do not make an effective business case at the present time, but given the technology progress in the next few years, these materials can become viable. Any lack of research to understand the use of these materials becomes a big hurdle in the future. This reviewer observed a good balance between the mid- and long-term research and development (R&D) in the materials section.

Reviewer 2:
Based on priorities and technology readiness levels (TRL), this reviewer commented that the program is well-balanced between short- and long-term goals.

Reviewer 3:
This reviewer found it difficult to assess an appropriate balance between near-, mid-, and long-term R&D because research timelines were not presented.

Reviewer 4:
The reviewer indicated no; focus was predominately on accomplishments and there was a lack of mid- and long-term planning.

Reviewer 5:
Little description between the near-, mid-, and long-term research was reported by this reviewer, who added that this point was not covered well.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer responded positively and explained that the important issues (e.g., cost, predictability tools for optimum design, joining, recycling, etc.) were clearly identified for each of the material systems.

Reviewer 2:
This reviewer stated well done; primary issues for the wide range of material systems were identified and priorities were established.

Reviewer 3:
The reviewer remarked that important challenges and the most important technological opportunities to address those challenges were clearly identified.

Reviewer 4:
The important issues were clearly identified from this reviewer's perspective.

Reviewer 5:
This reviewer stated no: 10% mass reduction results in 6%-8% reduction in fuel; and higher combustion pressures result in increased high temperature material properties. The reviewer emphasized that the lower relative cost of increasing combustion efficiency resulting from increased cylinder pressure and fuel reduction due to mass reduction relative to competing technologies (e.g., electrification and lightweighting) is important to illustrate. Lightweighting is around $2.50/pound (lb) saved and the cost of batteries at $240/kilowatt-hour (kWh) is equivalent to $5/lb saved. The reviewer explained that if the cost of batteries is reduced to $120/kWh, lightweighting at $2/lb saved is a push.

Additionally, the reviewer opined that the environmental impact imposed by the production of Mg using electrolytic reduction and the high production rates of ZEK100 warm-formed Mg sheet need to be identified as a Mg cornerstone. Rather, VTO is proposing AZ31 sheet, which uses the 3 min/part quick plastic forming process.

Although the recyclability and short molding times associated with carbon fiber-reinforced polymer (CFRP) need to be identified as a cornerstone, this reviewer noted that VTO is proposing thermoset resin and continuous fiber/fabric. The reviewer highlighted the environmental impact and long cycle time associated with thermoset.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
This reviewer stated yes; the effort to collaborate with other consortiums (e.g., like LightMAT) and advanced facilities available at the national laboratories were provided.

Reviewer 2:
The reviewer described future research areas as clearly identified and acknowledged that specifics were not provided because this was an overview presentation.

Reviewer 3:
This reviewer indicated that the Materials Technology Roadmap identifies key issues related to the broad range of automotive materials and research needs. However, plans to address these specific needs were not detailed.

Reviewer 4:
The reviewer reported that the only plans identified are the LightMAT and HPC4Mfg programs, which can enable future projects, but are not clear plans for addressing issues.

Reviewer 5:

This reviewer stated no. Firstly, the reviewer pointed out that the carbon (C) footprint associated with reduction of magnesium oxide (MgO) using the Pidgeon process is not identified or listed as an issue/challenge. Additionally, the supply risk associated with Mg ingot, as well as the cost and environmental impacts of Mg reduced using electrolytic reduction in the U.S. and Canada are not discussed.

Secondly, this reviewer highlighted that the long cycle time (3 min/part) of using “quick plastic forming process” to form Mg sheet and the issue of long cycle time associated with quick plastic forming of AZ31 Mg sheet are not identified as issues/challenges. Cycle time results in high cost; the alternative cycle time (10 sec/part) of warm forming ZEK100 Mg sheet is not presented.

Thirdly, the reviewer noted that recyclability of thermoset resins (1 useful life) is not identified as an issue/challenge. The lack of recyclability presents high C footprint, and the alternative recyclability of thermoplastic resin is not presented.

Fourthly, the reviewer indicated that long cycle time (3 min/part) of using “compression molding process” to form CFRP is not identified as an issue/challenge. The alternative of injection molded chopped fiber thermoplastic is not presented.

The reviewer offered the following alternative solutions: electrolytic reduction of MgO, ZEK-alloy enables warm forming (10 sec/part), and domestic supply of ingot and sheet; or injection molding process using chopped fiber and thermoplastic resin, which addresses cost and recyclability of thermoset and continuous fiber. With respect to the latter proposed solution, the reviewer acknowledged the uniform distribution and orientation of CF challenges that need be addressed.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

This reviewer commented that more information may be needed regarding the progress achieved. Also, it may be difficult to provide progress in a year-long time span because these efforts usually become fruitful with large improvements after a few years.

Reviewer 2:

There was no clear benchmarking of technical progress from 2017 to 2018 observed by this reviewer, just the budget numbers.

Reviewer 3:

This reviewer responded negatively and reported that benchmark data was not presented.

Reviewer 4:

The reviewer remarked that broad program areas were covered and specific comparisons to last year’s work were not performed.

Reviewer 5:

This reviewer responded negatively and indicated that this does not appear to be an objective of this particular presentation.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

This reviewer stated yes; the materials technology mission of automobile lightweighting directly benefits fuel economy, energy independence, and emissions, which are broad problems that VTO is trying to solve.

Reviewer 2:

While specific technical programs are not listed or addressed by the MAT918 overview, this reviewer commented that the breadth of technical projects presented at the AMR clearly addresses the broad range of technologies outlined by the presentation. It is apparent to this reviewer that VTO is funding relevant research in all of the challenge areas identified by this presentation.

Reviewer 3:

It was clear to this reviewer that the program is well thought-out. Some new, well-considered programs also were introduced (e.g., LightMAT). The reviewer advised that VTO judiciously invest in high-performance computing (HPC)-type programs because several materials development problems are not scalable on big, powerful machines. This is different from problems like finite element modeling or computational fluid dynamics where more computing power provides more refined answers.

Reviewer 4:

The reviewer responded negatively and pointed out that many VTO projects are focused on Mg/steel, CFRP/steel, AZ91 Mg alloy, continuous fiber, and thermoset resins.

Reviewer 5:

This reviewer explained that the projects are not identified by category or by technology, and there is no information on a strategy or overarching plan to reduce weight and improve platinum (Pt) materials.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer emphatically replied yes and described the materials technology program as very focused, well-managed, and very effective in addressing VTO needs.

Reviewer 2:

This reviewer stated yes; the program area most certainly appears to be focused, well-managed, and effective in addressing VTO needs. With specific lightweight materials program work in all areas of need and progress reported throughout the AMR, the reviewer asserted that the management team is doing an adequate job in a focused and effective manner.

Reviewer 3:

The reviewer observed a critical program that takes industry input to develop roadmaps and reports and then manages an effective portfolio to address the challenges identified in the roadmaps.

Reviewer 4:

This reviewer stated no.

Reviewer 5:

The program did not appear to be well-focused from this reviewer's perspective. The roadmap is a good start, but the reviewer noted that funding or accomplishments against this roadmap were not presented here.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer described the following as strengths: the VTO Materials technology program for automobiles is better managed to get results compared to materials programs in other sectors like aerospace; the complexity of VTO Materials program challenges compared to other programs; and the probable value of technology developed under VTO auspices compared to other sectors like aerospace. This reviewer stressed that reduction in funding could be a significant weakness going forward.

Reviewer 2:

The reviewer commented that a key programmatic strength is the strong industry interaction and the weakness as presented was a focus on HPC without justification of how and/or why this is a critical area for materials development. Further, it was difficult for this reviewer to judge individual projects based on the examples provided.

Reviewer 3:

Because the projects are not clearly identified, the reviewer was at a loss to answer this question. What the Advanced Joining Consortium does as well as its corresponding projects and/or budget was unclear to this reviewer. The efforts for HPC4Mfg and LightMAT are good vehicles for addressing point needs, but are not set up to make strategic leaps forward in lightweighting or powertrain materials.

Reviewer 4:

This reviewer found insufficient content in the MAT918 presentation to effectively comment.

Reviewer 5:

The demonstrated ability to focus Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL) on topics was described by this reviewer as a key strength. Conversely, the reviewer identified the following weaknesses: many CFRP projects focus on thermoset resins and continuous CF; many Mg projects focus on AZ91 alloy; joining themes are focused on AZ91 Mg alloy and joining Mg and CF to steel; and funding is aimed at supporting lab research. This reviewer explained that industry receives no cash and only provides in-kind labor, which limits industry engagement.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

This reviewer stated yes; projects related to advanced materials (e.g., CFCs, Al, and high-strength steel [HSS]) and joining of dissimilar materials are game changing for automotive industry vehicle lightweighting and improved fuel economy.

Reviewer 2:

The overall direction and scope of the program were encouraging to this reviewer, although no specific project related information was presented.

Reviewer 3:

This reviewer commented that there was not sufficient content in the MAT918 presentation to effectively comment.

Reviewer 4:

The reviewer was at a loss to answer this question because there was no project information.

Reviewer 5:

This reviewer stated that these projects do not represent novel and/or innovative ways to approach these barriers appropriately.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:
The reviewer remarked that this program has been successful in engaging with national laboratory, industry, and university partners in the past and continues to do that.

Reviewer 2:
This reviewer responded positively and reported that the materials program adequately engages academia, national laboratories, and industry.

Reviewer 3:
The reviewer indicated that national laboratories, domestic automotive original equipment manufacturers (OEMs), tier one suppliers, academic institutions, and subject matter experts all participate. While the mix of involvement from each type of partner may be questioned, this reviewer described it as comprehensive and complete.

Reviewer 4:
This reviewer stated yes, though university and industry partner engagement are limited due to lack of funding received by industry.

Reviewer 5:
The community is strong and interested as noted by this reviewer, who also acknowledged the partners and typical players from other AMR presentations. The reviewer further observed waning engagement the last couple of years, perhaps because the vision is not clear enough.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:
Based on participation level, it was clear to this reviewer that the collaboration is both effective and productive.

Reviewer 2:
The reviewer responded positively and observed effective collaborations.

Reviewer 3:
This reviewer stated yes.

Reviewer 4:
The reviewer asserted that program personnel engage well with industry and university personnel, but pointed out a lack of industry engagement due to lack of funding.

Reviewer 5:
This reviewer expressed that it was hard to tell.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer was encouraged to see materials development being emphasized; it is an area where continued emphasis will bear fruit for the program. This reviewer also suggested that efforts in the area of additive manufacturing will be useful.

Reviewer 2:
No glaring gaps were observed by this reviewer. The program is well-conceived and the breadth is encompassing. The reviewer recommended more attention on means and methods of low-cost manufacturing,

thereby enabling implementation of key lightweighting and powertrain technologies, which may be the only component potentially benefitting from greater focus.

Reviewer 3:

This reviewer indicated that the materials program should add some battery system materials to its portfolio to improve design and cost efficiency of battery systems.

Reviewer 4:

The reviewer reported that the roadmap identifies gaps and opportunities for lightweight vehicle needs.

Reviewer 5:

This reviewer stated yes and emphasized that the energy efficiency portfolio gap is focusing on system efficiency. One group works on battery chemistry, another on charging, another on motor design, and another on lightweight materials. The reviewer also noted the following gaps: vehicle system efficiency; and driveline efficiency (design and reduced frictional losses)

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

This reviewer could not think of any topics that are being inadequately addressed.

Reviewer 2:

The reviewer stated well done and was very impressed with the breadth of topics reviewed at the AMR. This reviewer pointed out there is a C-centric focus to the non-metallic lightweighting materials efforts, and suggested possible value in considering a range of reinforcements, hybrids, or simple geometry to exploit other low specific gravity engineering materials, including glass fiber reinforcements.

Reviewer 3:

This reviewer remarked that some examples of existing project successes would be useful for future overview presentations.

Reviewer 4:

System efficiency and driveline efficiency/energy recovery were highlighted by this reviewer.

Reviewer 5:

There appeared to be a lack of implementation and verification projects from the reviewer’s perspective. The best project area would integrate a number of previously developed technologies into a demonstration and/or verification project to see if the solutions were robust.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

This reviewer advised that it may be useful to consider a set of topics that begin large-scale integration of lightweighting technologies. The reviewer further explained that this would achieve significant part integration in monocoque body and chassis design such that the expected higher material costs of lightweight composites and metal alloys can be offset by significant part count and integration of major sub-assemblies.

Reviewer 2:

The question was difficult for this reviewer to answer because the funding is unclear against the roadmap. The reviewer observed great need for an integration and verification project to combine a number of technologies.

Reviewer 3:
This reviewer recommended additive manufacturing and materials development as two key areas to emphasize.

Reviewer 4:
The reviewer listed the following areas that this program area should consider funding to meet overall programmatic goals: driveline efficiency; overall vehicle system efficiency; and cradle-to-grave lifecycle.

Reviewer 5:
This reviewer identified the following areas: advanced lightweight materials for battery systems; lightweight material architectures for battery vehicles to meet performance requirements; CF component certification protocols development for automotive industry; and prognosis of composite systems manufacturing to reduce manufacturing costs.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:
The reviewer asserted that existing approaches are sufficient and hoped for sustained funding in the key area of materials as part of the portfolio.

Reviewer 2:
This reviewer recommended more funding and more collaboration with the OEMs.

Reviewer 3:
The reviewer suggested challenging projects to integrate and verify the technologies.

Reviewer 4:
This reviewer explained importance of aligning the commercial needs that automotive OEM's must meet with the technical objectives established by the program area. Lightweighting is not necessarily the first thing that comes to mind new vehicle consumers. The reviewer opined that more public education such that consumers demand products aligning with these attempts to improve efficiency, reduce embodied energy, and expand lightweight material use can go a long way toward positively affecting the products that roll off the assembly line going forward. DOE can drive the technical program by solicitation and funding, but the reviewer asked what the point would be if this does not result in consumer-accepted products.

Reviewer 5:
The reviewer noted the following: overall system efficiency; driveline efficiency; and cradle-to-grave lifecycle.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:
This reviewer suggested more communication of the knowledge and improvements achieved from this materials program to the entire automotive industry supply chain for more efficiency.

Reviewer 2:
The reviewer suggested that the presentation itself would benefit from a listing of the active program area projects and the specific goals expected from each. It would provide a holistic view of the program area activities and enable a more effective "gap" analysis. The reviewer clarified that this was not a very strong criticism by any means.

Reviewer 3:

This reviewer advised that emphasizing early stage, national laboratory research that can be translated to industry in later years will lead to out-of-box solutions. Sustained funding at the national laboratories will be important to achieve the programmatic goals.

Reviewer 4:

This reviewer remarked that a clear vision of success would greatly help focus this effort.

Reviewer 5:

The reviewer commented to enforce go/no-go milestones. The reviewer asserted that this should be an administrative decision to continue funding.

This reviewer also suggested expanding the theme to mobility systems, which includes alternate forms of transport (e.g., drone delivery, drone personal transport, and first mile/last mile transit in an urban environment). The project funds would need to sufficiently support a project team comprised of multiple disciplines, industry, university, and government lab personnel over a period between 3 and 5 years. The reviewer commented that the Multi Material Lightweight Vehicle (MMLV) project size is a good example (i.e., $20 million over 3 years, 50% funded by DOE, 50% by industry). The reviewer also advised to increase the funding ratio to 80% if VTO wants to encourage more university or DOE lab involvement.

Battery-powered drone personal transport development was offered by this reviewer as a project example. The project would deploy the latest lightweight materials and joining processes including CFRP, Mg, friction stir welding (FSW), artificial intelligence (AI), and chemical-toughened glass.

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.

Table 6-1—Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
mat053	High-Temperature Engine Materials: Valve Materials Subtask	G Muralidharan. (ORNL)	6-16	3.33	3.33	3.33	3.00	**3.29**
mat057	Applied Computational Methods for New Propulsion Materials	Charles Finney (ORNL)	6-19	3.00	2.67	2.33	2.83	**2.73**
mat060	ICME Guided Development of Advanced Cast Aluminum Alloys for Automotive Engine Applications	Mei Li (Ford)	6-22	3.38	3.25	3.00	N/A	**3.25**
mat061	Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines	Mike Walker (General Motors)	6-25	3.00	2.63	3.00	1.50	**2.63**
mat069	Lightweight High-Temperature Alloys Based on the Aluminum-Iron-Silicon System	Michelle Manuel (U. of Florida)	6-28	3.17	3.50	3.00	2.67	**3.25**
mat101	Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles	Xuming Su (Ford)	6-32	3.13	3.38	3.13	3.13	**3.25**
mat113	Magnesium Corrosion Characterization and Prevention	Mike Brady (ORNL)	6-36	3.33	2.83	3.50	3.17	**3.08**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
mat117	Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications	Venkat Aitharaju (General Motors)	6-39	3.50	3.38	3.25	3.25	**3.38**
mat118	Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly	Srikanth Pilla (Clemson U.)	6-43	3.00	3.13	3.25	2.75	**3.06**
mat119	Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration	Nate Gravelle (TPI)	6-46	3.00	3.17	3.67	3.17	**3.19**
mat122	Low-Cost Carbon Fiber Research Using Close Proximity Electromagnetic Carbonization (CPEC)	Felix Paulauskas (ORNL)	6-49	3.10	2.90	2.90	2.90	**2.95**
mat124	Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber for Lightweight Vehicles	Xiadong Li (U. of Virginia)	6-53	3.38	3.00	3.25	3.00	**3.13**
mat125	Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber	Donald Collins (Western Research Institute)	6-57	3.38	2.75	3.38	3.25	**3.05**
mat126	Room-Temperature Stamping of High-Strength Aluminum Alloys	Aashish Rohatgi (PNNL)	6-60	3.33	3.33	3.33	3.33	**3.33**
mat127	USAMP Low-Cost Magnesium Sheet Component Development and Demonstration Project	Stephen Logan (FCA)	6-64	2.88	2.88	3.38	3.13	**2.97**
mat128	Development of Low-Cost, High-Strength Automotive Aluminum Sheet	Russell Long (Arconic)	6-68	3.38	3.50	3.13	3.13	**3.38**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
mat129	Optimizing Heat-Treatment Parameters for 3rd Generation Advanced High-Strength Steel Using an Integrated Experimental Computational Framework	Xiaohua Hu (PNNL)	6-72	3.00	2.83	3.00	2.67	**2.88**
mat130	Enhanced Sheared Edge Stretchability of Advanced High-Strength/Ultra-High Strength Steels	Kyoo Sil Choi (PNNL)	6-76	2.88	2.75	3.00	2.50	**2.78**
mat131	Corrosion Control in Carbon Fiber Reinforced Polymer Composite—Aluminum Closure Panel Hem Joints	Brian Okerberg (PPG Industries)	6-80	2.92	3.08	3.17	3.08	**3.05**
mat132	High-Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding	Glenn Daehn (Ohio State U.)	6-84	3.67	3.50	3.50	3.50	**3.54**
mat133	Corrosion Protection and Dissimilar Material Joining for Next-Generation Lightweight Vehicles	DJ Spinella (Arconic)	6-87	3.33	3.17	3.17	3.00	**3.19**
mat134	Assembly of Dissimilar Aluminum Alloys for Automotive Applications	Piyush Upadhyay (PNNL)	6-90	3.25	3.38	3.38	3.38	**3.34**
mat135	Technology Validation of Innovative Dissimilar Materials Joining Method in Automotive Production Environment	Zhili Feng (ORNL)	6-93	3.00	3.00	3.20	2.90	**3.01**
mat136	High-Performance Computing and High-Throughput Characterizations towards Interfaces-by-Design for Dissimilar Materials Joining	Xin Sun (ORNL)	6-97	2.80	2.90	3.20	2.90	**2.91**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
mat137	Adhesive Bonding of Carbon-Reinforced Plastic to Advanced High-Strength Steel	Amit Naskar (ORNL)	6-101	2.90	3.10	2.90	3.30	**3.05**
mat138	Solid-State Joining of Magnesium Sheet to High-Strength Steel	Glenn Grant (PNNL)	6-105	3.50	3.30	3.00	3.30	**3.31**
mat139	Joining Magnesium Alloys to Carbon Fiber Reinforced Polymers	Scott Whalen (PNNL)	6-109	3.20	3.30	3.30	3.10	**3.25**
mat142	Metal Matrix Composite Brakes Using Titanium Diboride	Glenn Grant (PNNL)	6-113	3.33	2.83	3.33	3.00	**3.04**
mat143	Mitigating Corrosion in Magnesium Sheet in Conjunction with a Sheet-Joining Method that Satisfies Structural Requirements within Subassemblies	Aashish Rohatgi (PNNL)	6-116	3.00	3.00	3.33	2.67	**3.00**
mat144	Reducing Mass of Steel Auto Bodies Using Thin Advanced High-Strength Steel with Carbon Fiber Reinforced Epoxy Coating	Dave Warren (ORNL)	6-119	3.30	3.30	3.50	3.10	**3.30**
mat145	Joining Core Program Overview	Richard Davies (ORNL)	6-123	3.30	3.40	3.20	3.20	**3.33**
Overall Average				**3.17**	**3.11**	**3.19**	**3.05**	**3.12**

Presentation Number: mat053
Presentation Title: High-Temperature Engine Materials: Valve Materials Subtask
Principal Investigator: G. Muralidharan (Oak Ridge National Laboratory)

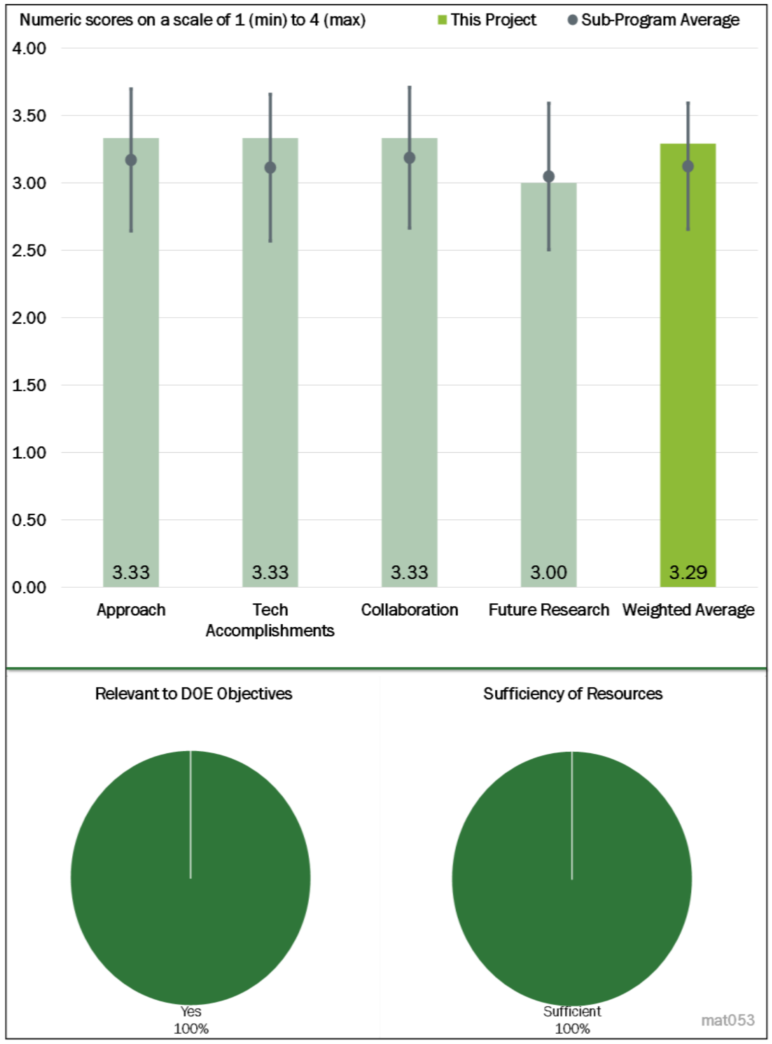

Figure 6-1 - Presentation Number: mat053 Presentation Title: High-Temperature Engine Materials: Valve Materials Subtask Principal Investigator: G. Muralidharan (Oak Ridge National Laboratory)

Presenter

G. Muralidharan, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the principal investigator (PI) and the team have a good plan to investigate how to promote a higher temperature nickel (Ni)-based super alloy that can possibly avoid the degradation of γ’ at increasing temperatures.

Reviewer 2:

The reviewer stated that materials allowing high (greater than 950° C) exhaust temperatures are a barrier to power density and efficiency.

Reviewer 3:

The reviewer commented that the team has made very good progress on evaluating multiple alloy combinations, from the past chromia formers to the latest alumina formers. The combination of mechanical property testing, oxidation studies, and scanning electron microscopy imaging is able to quickly evaluate and select the best designs to go forward. However, there appears to be a lack of computational thermodynamics and density functional theory work that may help with finding new elemental combinations for testing.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked that Govindarajan and the team are making good progress considering this program just started. The reviewer expressed confusion about one slide that mentioned that the higher chrome led to higher alumina growth, etc. Otherwise it looks like the PI and the team are measuring everything against the benchmark.

Reviewer 2:

The reviewer commented that the team has come up with improved alloy combinations that are better than the commercial alloys. The team's alumina-forming alloys double the commercial alloys' strengths. The reviewer pointed out, however, that these alloys' strengths still need to double to compete with chromia alloys, and cost needs to be evaluated, especially with the use of cobalt.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that the PI has very good communication and coordination skills.

Reviewer 2:

The reviewer acknowledged that it is a challenging task to get specialty produced valve stock. The research team appears to be able to create the designed alloys, get them produced, heat treated, and machined for testing. The reviewer noted that required tests are carried out in a timely manner for the project to progress forward. However, the reviewer observed a lack of resources on the computational thermodynamic side that could be used to identify new compositions.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that future research focuses on developing varies alloys with potential higher strength and oxidation resistance and down-selecting the best one for larger scale testing. The reviewer saw that the selection process is fine. However, the reviewer did not see how the team intends to develop the new chemistry. From what was shown, it appears more trial and error rather than a methodical method to achieve the goal. The reviewer said that the team is now focusing on the alumina formers and although the team has made very good strides in achieving strengths, it still needs to double the strength that they have. The reviewer exclaimed, that is a lot.

Reviewer 2:

The reviewer suggested that the project team maybe incorporate carbide formers (C, chromium, molybdenum, tungsten, niobium, tantalum, titanium [Ti], and hafnium. The carbides tend to precipitate at grain boundaries and hence reduce the tendency for grain boundary sliding at higher temperatures to mitigate risk.

Reviewer 3:

The reviewer inquired what the down-selection criteria are.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that the project supports DOE objectives to create higher temperature materials to increase engine efficiencies.

Reviewer 2:

The reviewer noted that DOE objectives are based on increasing engine efficiency by enabling higher temperatures and pressures in the engine. Higher temperatures and pressures require valves to be able to sustain higher temperatures, and this project is attempting to do that.

Reviewer 3:

The reviewer pointed out that power density and efficiency are often limited due to material limits at high exhaust temperatures.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed that ORNL and the material suppliers have enough resources to achieve their goals. The reviewer thinks that ORNL may need to add resources in the integrated computational materials engineering (ICME) area to reach the final goal.

Reviewer 2:

The reviewer suggested asking Lou Hector, Jr., a General Motors (GM) Technical Fellow in the Chemical and Materials Systems Lab at the General Motors R&D Labs in Warren, Michigan, to join your team. The reviewer detailed that Lou conducts research in engineering materials such as AHSS and, in this reviewer's opinion, Lou could definitely apply his amazing talents to move this program in a timely fashion.

Presentation Number: mat057
Presentation Title: Applied Computational Methods for New Propulsion Materials
Principal Investigator: Charles Finney (Oak Ridge National Laboratory)

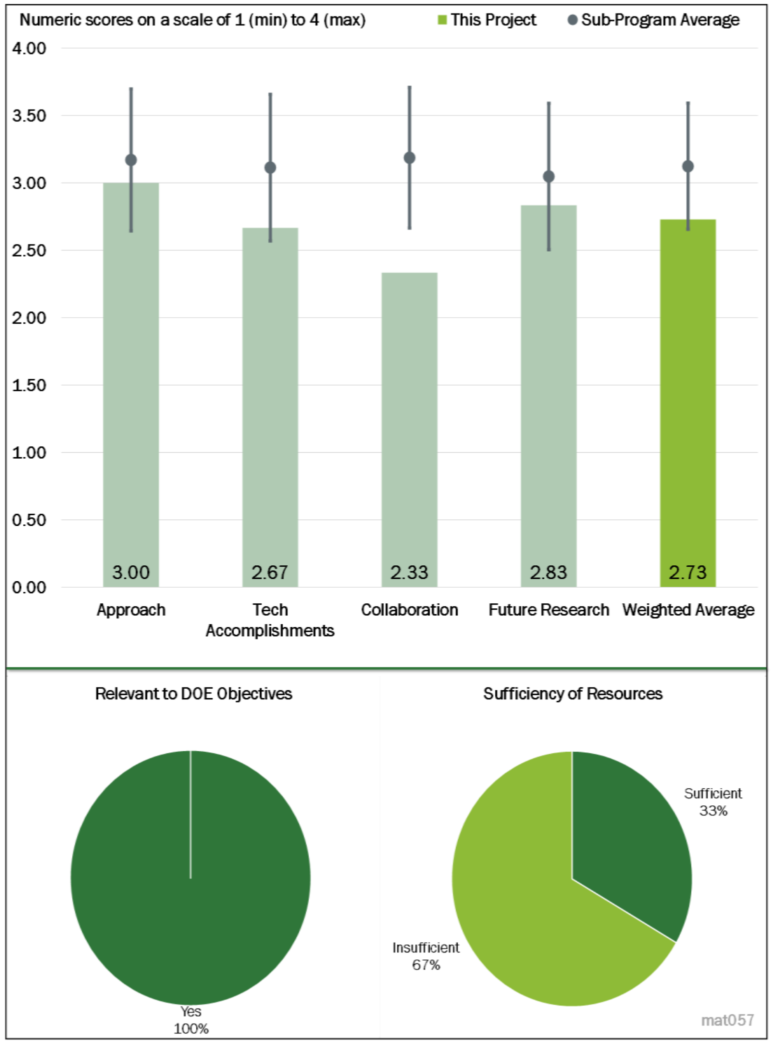

Figure 6-2 - Presentation Number: mat057 Presentation Title: Applied Computational Methods for New Propulsion Materials Principal Investigator: Charles Finney (Oak Ridge National Laboratory)

Presenter

Charles Finney, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the project team's approach, which compares standard low-order modelling to the slower high-order modelling, is well thought of. For one, it will identify the limitations of the lower order model as well as identify the most important areas in the high order modelling. The reviewer noted that the project team is also looking at comparing multiple real materials for validation.

Reviewer 2:

The reviewer remarked that the combination of measured physical properties, complex simulations, and super computers promise to make progress on material property improvements.

Reviewer 3:

The reviewer acknowledged that the PI has a plan for the program, but opined that some upfront data material testing data requirements need to be addressed before looking at the cylinder head component specifically.

The reviewer said that Charles has looked at fatigue at higher temperatures (greater than 400°C) and claimed that the creep behavior is causing the loss of fatigue strength. However, the team needs to understand that this is a wonderful opportunity to create a mathematical model that combines both the fatigue (Coffin-Manson) and creep (power law) deformation mechanisms of the compacted graphite iron (CGI) material at high temperatures and pressures.

The reviewer suggested looking at the following equations to start: $\varepsilon = A \exp(-Q/RT)\, \sigma^n\, t^m$, where n and m are the stress and time hardening exponents, Q is the activation energy (kJ mol^{-1}), R is the universal gas constant (8.314 J $mol^{-1}K^{-1}$), and A is constant; and (delta e / 2) = $e'_f(2N_f)^c$, where delta e / 2 is the total strain amplitude, e'_f is the fatigue ductility coefficient, $2N_f$ is the number of reversals to failure, and c is the fatigue ductility exponent.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed some data, but indicated that the team also needs to look at the CGI cylinder head from a thermal dynamic point of view because the cooling, heat, and stress on the bridge between the exhaust valves are allowing a residual stress to set up in the material. The reviewer noted that the fatigue crack usually initiates at the cooling line. The reviewer observed that Charles and the team could them use the above fatigue and creep data and using a Goodman diagram-type relation determine the deformation behavior for the cylinder head.

Reviewer 2:

The reviewer noted that the development of the models is complete as well as some data analysis. However, given that the program started in 2014 and will be completed in 2019, the project has only shown very little results. The reviewer remarked that the team still needs to get the high-order simulations into the high-power computer.

Reviewer 3:

The reviewer was unclear where the creep information came from. The reviewer noted that progress is being made toward the ultimate program goal.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed that the presentation listed partners, but it was not clear to this reviewer what their role is and how they contribute to the project.

Reviewer 2:

The reviewer remarked that the program is just starting so it appears to the mostly ORNL-centric at this time. However, the reviewer suggested inviting Westmoreland Mechanical Testing and Research, Inc. to assist with some of the fundamental material testing. The reviewer also suggested maybe a casting simulation partner (Magmasoft, EKK, etc.) to determine the quality of the CGI cast material, etc.

Reviewer 3:

The reviewer acknowledged that the ORNL team appears to be working with the simulation group well, but the reviewer did not see much in the way of results with the OEMs. The reviewer asked what the OEM's are providing in the project, and if they are getting information that is useful to them. The reviewer remarked that there needs to be more results from the high-order simulations to show what is needed for a material.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed good future plans, and that it would be good to apply this same approach to an Al block and cylinder head.

Reviewer 2:

The reviewer stated that this is a very interesting but challenging program for ORNL. The team needs to understand the fundamental material deformation behavior and then can offer improvements to the powertrain component itself.

Reviewer 3:

The reviewer said that fully implementing models is critical to the project and is a stated future goal. The reviewer cited that the team plans to get full creep/fatigue for CGI, but the team also needs to get results for gray cast iron. Furthermore, rather than just getting results, what is needed, and the purpose of the project, is identifying what is needed in future materials. The reviewer specified what are the limitations in horsepower with thermoconductivity, strength, and fatigue strength; and at what temperature is fatigue strength most important.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer agreed that tis work supports the DOE objectives by the development of more efficient engines that operate at higher temperatures and pressures.

Reviewer 2:

The reviewer noted that improved materials can lead to improved engine designs for increased efficiency.

Reviewer 3:

The reviewer said that it is easy to say that we need better materials for higher power engines, however, materials always have tradeoffs of one property for another. The reviewer pointed out that engine simulations need to be used to identify material weaknesses and develop both design and materials strategies, and that this work aims to do that.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that resources are adequate for the project.

Reviewer 2:

The reviewer suggested bringing in a CGI industry expert(s) as early as possible in order to develop a strategy going forward.

Reviewer 3:

The reviewer said that the high-order simulations are moving too slowly. Because the team cannot get the simulations running on the high-power computers, the team appears to be limited on what can be accomplished.

Presentation Number: mat060
Presentation Title: ICME Guided Development of Advanced Cast Aluminum Alloys for Automotive Engine Applications
Principal Investigator: Mei Li (Ford)

Presenter
Mei Li, Ford

Reviewer Sample Size
A total of four reviewers evaluated this project.

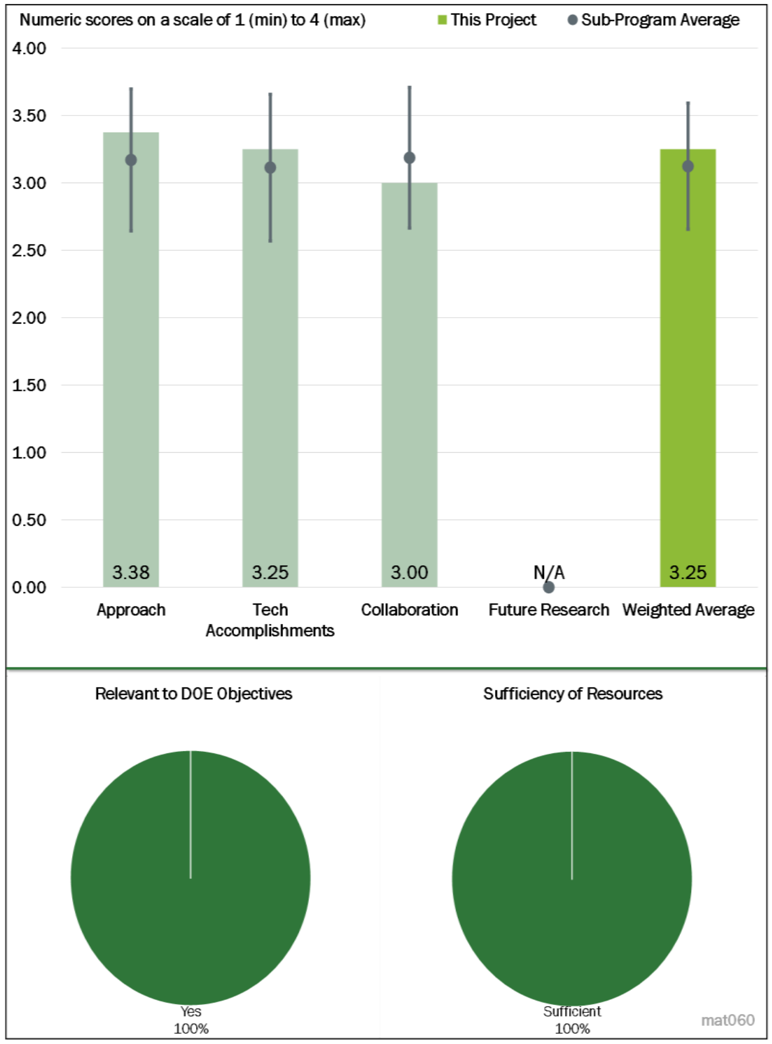

Figure 6-3 - Presentation Number: mat060 Presentation Title: ICME Guided Development of Advanced Cast Aluminum Alloys for Automotive Engine Applications Principal Investigator: Mei Li (Ford)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer remarked that the project was well-designed and thorough. The PI and her team were obviously very capable and had a clear understanding of how to apply ICME methods to the targeted materials. The reviewer described that when the results did not lead to the original goals, the team made a high value pivot to successful development of two new alloys and the associated heat treatments. The reviewer noted that both alloys were demonstrated on prototypes. A quite thorough gap analysis was provided in the presentation, although unfortunately there was not time to discuss during the presentation. The reviewer said that frankly, this was such a valuable presentation for discussion of ICME that it should have been given a full time slot at the meeting, rather than only 15 minutes.

Reviewer 2:
The reviewer said that the approach is good to combine alloy simulation with casting trials and testing parts.

Reviewer 3:
The reviewer acknowledged that this was the very end of the project. The reviewer said that it appeared that Mei Li and the Ford team did a very good job planning the ICME approach to vanadium (V) and zirconium to Al high-temperature alloys. The project team looked at increasing the strength by investigating L12-structured Al_3Zr phase.

Reviewer 4:
The reviewer said that as this project is wrapping up, few details were provided in the presentation to judge the approach.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer detailed that two new alloys were developed and demonstrated on prototype components. The reviewer said that is an excellent return on investment in only 4 years, and that the real proof of accomplishment will be eventual deployment of one or more of these alloys.

Reviewer 2:
The reviewer was impressed that Mei Li and the team took on so many tasks in a single R&D program, including alloy development for both low-pressure semi-permanent mold, and high-pressure die casting, subsequent heat treatment, etc.

Reviewer 3:
The reviewer noted good results with an improvement in alloy strength performance.

Reviewer 4:
The reviewer said that the investigators successfully developed an alloy and demonstrated these alloys on prototype components. The reviewer said that the presentation was successful in showing that results were received, but the insight that these results allowed the investigators to make were not always clear. This was particularly true in the ICME component of the project. The reviewer was not left with the impression that the computational work was "integrated," nor how these insights would be expanded upon or shared. The reviewer described that one of the more significant results expressed here and echoed in other talks was the observation that yield and ultimate strength were not the relevant properties to target as was set out in the initial program call, but that the fatigue properties were more relevant.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer found that the approach was very good and should be an example of a cross-functioning team of raw material producers, a casting simulation programmer, casting supplier, and non-ferrous ICME academia programs.

Reviewer 2:
The reviewer said that the roles and tasks taken on by the different partners were not clear.

Reviewer 3:
The reviewer remarked that partners were listed but it was not clear how partners are integrated into the project and what their roles and responsibilities are.

Reviewer 4:
The reviewer commented that the role of Magma was clear, but the roles of Alcoa, Nemak, and the University of Michigan were less clear.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the project ended.

Reviewer 2:
The reviewer remarked no future research was identified.

Reviewer 3:
The reviewer commented that the project is complete so no future work was outlined.

Reviewer 4:
The reviewer said end of project

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer agreed yes, this project is an excellent example of DOE strategically investing to stimulate and support high-risk/high-value materials development efforts to achieve superior new structural materials capable of withstanding more severe operating environments, thus supporting higher efficiency transportation technologies.

Reviewer 2:
The reviewer remarked that this work supports the DOE objectives by the development of lightweight powertrain materials.

Reviewer 3:
The reviewer commented that if cylinder head material can be improved, then engine designers can leverage this to reduce engine weight or improve engine efficiency. Both of these can reduce fuel usage.

Reviewer 4:
The reviewer stated that Al alloys that are stable at higher temperatures are relevant.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the team did a good job measuring the effects of the alloying elements against the benchmarks in both the theoretical and then actual experiments.

Reviewer 2:
The reviewer found that this project was adequately funded.

Reviewer 3:
The reviewer commented that resources and time were impressive, but still barely sufficient to develop new alloy concepts, although not quite sufficient to fully develop them. However, according to the reviewer this 5-year effort was an extremely rapid development process in the context of structural alloy development.

Reviewer 4:
The reviewer remarked that in some ways, the correct response would be “not applicable” as the project is ending.

Presentation Number: mat061
Presentation Title: Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines
Principal Investigator: Mike Walker (General Motors)

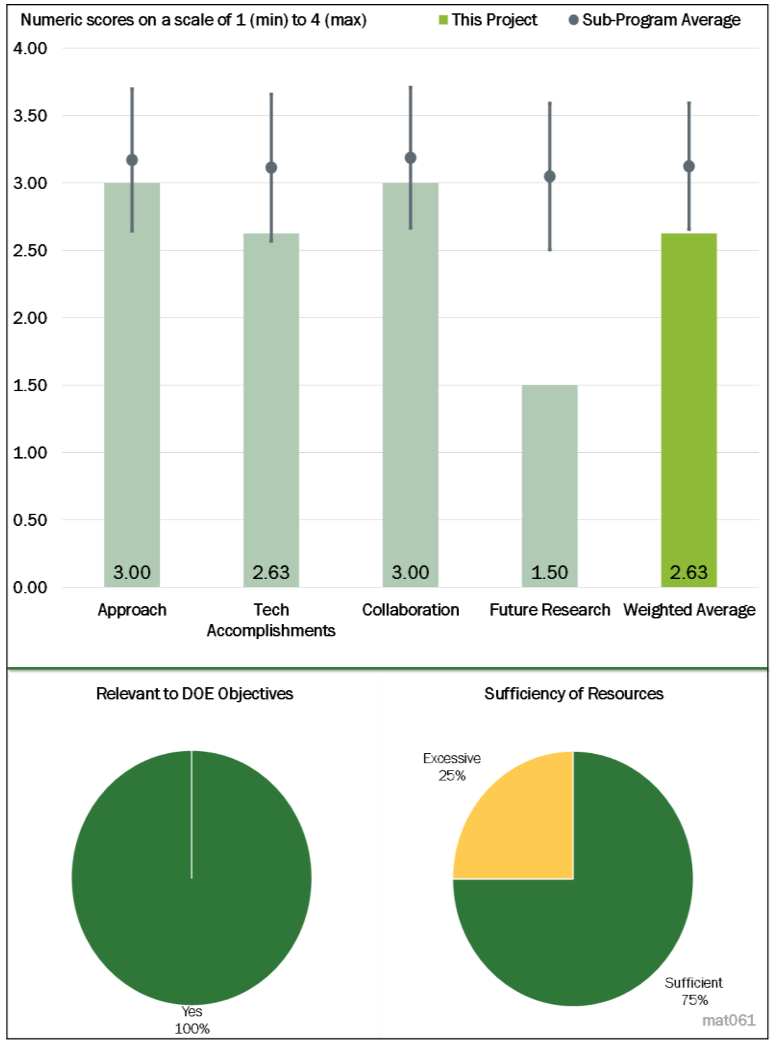

Figure 6-4 - Presentation Number: mat061 Presentation Title: Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines Principal Investigator: Mike Walker (General Motors)

Presenter

Mike Walker, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer pointed out that this was the very end of the program, and that it appeared the PI and the GM team did a good job planning the ICME approach to stabilizing the Q-phase in Al high-temperature alloys. The project team looked at increasing the strength by adding slower thermal diffusing alloying elements such as V and Ti.

Reviewer 2:

The reviewer said that the approach was thorough and the highly qualified team was well-suited for the effort. The team chose a high-risk strategy of an alloy with a stabilized Q-phase. The team achieved a significant advancement in alloy properties, but strength targets were not. The Q-phase proved not capable of providing the anticipated strengths at peak temperature. The reviewer pointed out that this outcome demonstrates the risk and difficulties associated with developing new materials. The reviewer said that the presenter did a very good job of making the case that fatigue strength was an even more important factor than yield strength (YS), ultimate tensile strength, and peak temperature.

Reviewer 3:

The reviewer said that this project is wrapping up, so the approach was not the focus of the presentation.

Reviewer 4:

The reviewer noted that testing new alloys is necessary to find better alloys.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the approach was good only during the ICME. The lattice frequency (temperature = 0 Kelvin) was not part of the overall computations and when the data were compared to the actual experiments, the team had issues reconciling the differences. The reviewer observed good progress and very interesting casting and fatigue results (the reviewer pointed out that it takes a long time to run fatigue testing).

Reviewer 2:

The reviewer commented that technical accomplishments were harder to discern as the presentation confusingly uses two different numbering schemes: alloy 1/2/3 and baseline 1/2. The reviewer noted that two trial alloys were developed and prototype castings were made. The reviewer pointed out that one of the more significant results that was expressed here and echoed in other talks was the observation that YS and ultimate strength were not the relevant properties to target. Processing parameters and fatigue properties were more relevant.

Reviewer 3:

The reviewer said that no alloys have been identified that improve high cycle fatigue.

Reviewer 4:

The reviewer commented that advances in high-temperature alloy properties were clearly achieved, and a very nice body of work on fatigue properties was conducted. The reviewer said it was clear that defect control during casting is a dominant issue that deserves more technical attention in future materials and processing studies.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer was clear that numerous team members had substantial roles, particularly Questek and Northwestern University. The integration of their modeling and characterization capabilities with GM’s design, manufacturing, and metallurgical expertise created a powerful team.

Reviewer 2:

The reviewer saw good collaboration within the existing team, but suggested that the team needed to add a more advanced casting simulation supplier in order to have run more casting simulations (e.g., Magmasoft, EKK, etc.) to determine the effect of the semi-permanent mold sand cooling rate on the fatigue/SDAS behavior on the material.

Reviewer 3:

The reviewer suggested that an industrial casting supplier could be added to address processing impacts on the behavior of the alloy.

Reviewer 4:

The reviewer said that though project roles were described, linkages between different groups and how the data were used was not as clear.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that the project ends June 2018. The future work identified seems reasonable and/or likely already complete.

Reviewer 2:
The reviewer said that when looking at fatigue variability, it appears to have surfaced late in the program. Some upfront screening using the University of Michigan's (J. Wayne Jones) ultrasonic frequency (20 kHz) fatigue testing might have been useful tool in order to mitigate risk.

Reviewer 3:
The reviewer said that the project is complete.

Reviewer 4:
The reviewer was not clear how the future plans will address the shortcomings of the proposed alloys so that the project objectives can be met.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer commented that development of new, more robust alloys for more severe engine operating environments supports DOE goals of higher transportation efficiencies.

Reviewer 2:
The reviewer cited development of Al alloys with improved properties at higher temperatures.

Reviewer 3:
The reviewer commented that this work supports DOE objectives by the development of lightweight powertrain materials.

Reviewer 4:
The reviewer said that if cylinder head materials can be improved, then engine designers can leverage this to reduce engine weight or improve engine efficiency. Both of these can reduce fuel usage.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer observed good resources expect maybe asking the University of Michigan (J. Wayne Jones) to do some upfront fatigue screening testing.

Reviewer 2:
The reviewer remarked that it appears additional resources would not have significantly impacted the outcome.

Reviewer 3:
The reviewer said "not applicable" is a more correct answer, as the project is ending.

Reviewer 4:
The reviewer said that spending should be stopped because the proposed alloys have not shown improved properties and the future plans do not address this.

Presentation Number: mat069
Presentation Title: Lightweight High-Temperature Alloys Based on the Aluminum-Iron-Silicon System
Principal Investigator: Michelle Manuel (U. of Florida)

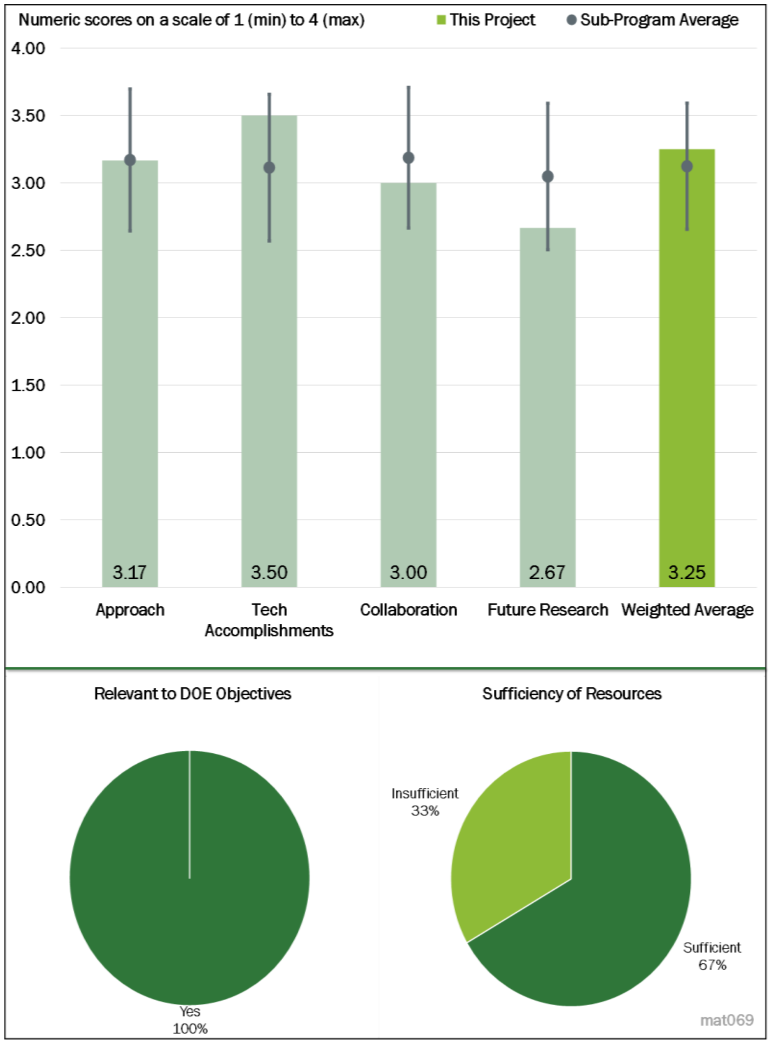

Figure 6-5 - Presentation Number: mat069 Presentation Title: Lightweight High-Temperature Alloys Based on the Aluminum-Iron-Silicon System Principal Investigator: Michelle Manuel (U. of Florida)

Presenter

Michelle Manuel, University of Florida

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach and research plan were explained well. The project uses computational and well-validated methods of alloy development. The reviewer remarked that the project seems high-risk/high-reward, but seems to lack go/no-go options if the project hits a significant barrier.

Reviewer 2:

The reviewer said that the approach to performing the work falls well within the category of “very good” or “excellent” from a purely academic viewpoint, but the practicality of the program as a whole seems somewhat undefined. This is not to take away from what is being accomplished, which appears to be substantial, and the qualifications of the team, which are clearly more than adequate. The reviewer said that the selection of the τ_{10} intermetallic still needs some clarification. The presentation, through the thoughtful and direct outlining of barriers given by the presenter, raised more concerns than it did to provide a clear path for success. A comparison of τ_{10} to such materials as titanium aluminides (TiAl) did little to convince the reviewer that the work has near-term relevance; the use of TiAl has been extensively researched for numerous applications and has gained little traction. The reviewer said that TiAl valves outprice valves produced by competing materials by a factor of 10-100. Nonetheless, the reviewer expressed interest in the work and looked forward to seeing progress made in this area that will elucidate the eventual use of the material. The reviewer said that at the moment, the defining of a program by microstructure seen through diffusion couples is a long distance from practical use and the reviewer would like to see that gap closed a bit.

The reviewer asked what is being drawn from the microstructures that were presented. The array of compositions side-by-side lacked some degree of visual evidence that there was a progression in microstructural behavior that could be extracted. The reviewer speculated that perhaps more magnifications showing larger areas, or detailed insets showing features of interest and their progression through a composition range, would have provided more information.

Reviewer 3:

The reviewer said that the approach to such a low TRL effort appears to be thorough, sound, and interesting. However, the core motivation for the project was not exactly clear, and somewhat unique for this meeting, because it focused on developing a narrowly stable intermetallic material for additive manufacturing of a high-temperature structural application that had not yet been identified. The reviewer noted that the objective of meeting or exceeding the high-temperature performance of a Ni-base superalloy is a noble goal. The reviewer was not clear from the presentation why the project team anticipated the alloy to be able to exceed the property set of Ni-based superalloys. For example, tensile properties for $Al_4Fe_{1.7}Si$ were shown to be superior to pure Ti and some variant of TiAl, but the temperature of measurements were not indicated, nor was the ductility. The reviewer acknowledged that the project is certainly at an early stage development, but it would have been more convincing to see a clearer presentation of what property set for $Al_4Fe_{1.7}Si$ was available to motivate this study. The emphasis on targeting this hexagonal closed packed (HCP) material for future laser printing was also interesting, because such laser-based processes are known to induce severe residual stresses—which are particularly problematic for intermetallics. The reviewer also pointed out that it seems the material is intended for higher temperature applications, but the issue of environmental resistance was not addressed or indicated as being of concern.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer identified great progress on the design/modeling component as well as the characterization of diffusion interfaces—these are critical aspects in this program. The screening component and equilibrium phase diagram analysis are also well-executed.

Reviewer 2:

The reviewer remarked that early stages of research have set a foundation for continued accomplishments, and that the experimental verification of the phase diagram and refinement of the thermodynamic databases seem to be good results.

Reviewer 3:

The reviewer commented that the progress toward creating greater stability in the targeted intermetallic phase was a good outcome. The combinatorial work and thermal analysis was valuable and appeared carefully conducted. The project is still early stage, so more results and accomplishments would be expected in future years. The reviewer said that because a material must be affordably manufacturable to be useful within the tight cost margins of the transportation market, the reviewer was somewhat concerned that the team had not given more thought to future larger scale manufacturing process(es) for which the new material(s) are being designed. The reviewer recognized that this observation must be balanced with the reality that this is very low TRL work in an academic setting. The reviewer cited discussion of converting from HCP to face-centered cubic structure with additions of copper (Cu) and manganese (Mn) on the last slide, but the reviewer was unclear if such work had shown promise in the combinatorial experiments where Mn was added. It will be very helpful to see tensile properties of key resultant materials, including elongation characteristics, next year. It will also be of value to see at least some preliminary data on environmental response at temperatures relevant to potential higher temperature powertrain applications.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that there appeared to be regular collaborations and communications with GM, and some neutron characterization work with ORNL.

Reviewer 2:

The reviewer said that as the majority of the work is “in house,” the barrier for successful collaboration is much lower. The reviewer said that overall guidance from GM and reaching out for specific measurements from ORNL seem to be good efforts.

Reviewer 3:

The reviewer acknowledged that the lead group seems largely capable of performing the work being presented, which is certainly commendable, but the effective use of additional resources is somewhat murky. The role of ORNL in beam-line work is certainly an effective additional capability, but the role of GM in the program is not entirely clear, despite the suggestion that an impressively regular meeting cycle exists with that industrial collaborator. The reviewer inquired if any fruitful suggestions or feedback coming from those meetings. The reviewer noted that it is quite possible that interim discoveries or potential new paths fall squarely into the proprietary information category, but the reviewer questioned if GM is really enamored with regular updates on microstructures and modeling approach layouts. The reviewer was not clear how this collaboration is elevating the practicality or effectiveness of the program.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

In this reviewer’s opinion, the layout of future work was both a strong point and a very weak point. There is an extremely logical flow to the tasks that were outlined, which is a strength of the project. The reviewer found, however, that the milestones and decision points lack a degree of distinct levels of accomplishment to be of any real value, despite the fact that they fit within the workscope and align well with the program overall. The reviewer said that the weakness lies in the generality of some of the areas being suggested—such as creating a list of chemistries as a go/no-go point. The reviewer remarked that one could create a list of chemistries while sitting at a desk that could be argued meets the objective of being producible or printable; it is the specific claims behind this list that would be compelling. The reviewer remarked that other areas are perfectly well-defined—such as the production of an additively manufactured specimen. The reviewer commented that nothing is left to speculation or hand-waving in that type of milestone.

Reviewer 2:

While the reviewer thought this project is good and should continue, the reviewer believed there are several items that could reduce the risk of this project. The reviewer detailed that as part of the question and answer, the PI indicated the team’s work thus far indicated that this alloy may be castable. That seems like an important research avenue to explore, as it would reduce cost to fabricate the parts and/or allow for more parts to be manufactured at a time. While the reviewer granted that casting is non-trivial, going through the additional steps for additive manufacturing (task 7, task 8) seems to invite problems that the alloy design may have already solved. The reviewer cited as one of the unexplored risks the brittleness of the alloy. The majority of intermetallics are notoriously brittle, which will affect their relevance for fatigue environments. The reviewer said that adding screening tests (either computational or experimental) that could be conduced to assess the brittleness of the alloy may help direct the alloy design to more rapid industrial use.

The reviewer expressed concern about the validation planned between task 8 and task 9. It seems that the elastic constants predicted in task 9 will be single crystal constants (3 for hexagonal), while the measurements performed in task 8 will likely be on highly oriented (due to additive manufacturing) polycrystal samples that may have additional phases and will only provide a single value (Young’s modulus [E]). The reviewer asked what will be a “successful” validation in this case. In addition, elastic modulus measurements also require large sample length for low uncertainty, which may be difficult to achieve with additive manufacturing.

Reviewer 3:

The reviewer remarked that future work is interesting as it involves manufacturing powders of morphology and volume suitable for additive manufacturing (which is not a trivial effort) and laser additively manufacturing test samples and measuring tensile properties. The reviewer said that it will be of interest to see whether stable structures are achievable at the quench rates of laser processing. The variable local thermal history due to repeated reheating during the sequential depositions of an additive process will likely impose some challenges on metastable materials dependent on rapid quenching. The reviewer said that it would seem to make sense to first test a cast quaternary material first and measure properties, prior to heavy investment in powder manufacturing of batches large enough to make additive test parts. The reviewer acknowledged that this is interesting work, but it does not seem to have clear targets. The reviewer thought that it would be very good to see a definition of more specific materials properties targets, including targeted operating temperatures and strengths at those temperatures.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that this project may develop a low-cost alloy with good high-temperature properties. The reviewer cited this project as a good example of a high-risk/high-reward project.

Reviewer 2:

The reviewer acknowledged that intermetallics present an entirely new list of headaches with regard to both manufacturing and durability, but the potential performance aspects and light weight in the rotating assembly make it worth pursuing thoughtful research. The reviewer noted that the extensive use of computational tools also indirectly supports DOE program goals on how to shape program efforts. It is good to see some DOE programs focused more on fundamental discovery to supplement the highly applied programs.

Reviewer 3:

The reviewer remarked the project offers some long-term promise of new structural intermetallics for higher temperature applications, possibly offering good specific strength. The reviewer commented that what applications are intended is not yet clear due to a lack of information on properties targets or even existing properties.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project is well supported.

Reviewer 2:

The reviewer found that the program is effectively leveraging the industrial partner for otherwise costly material production; the University of Florida is handling project execution using its considerable facilities and a large modeling/simulation component, which naturally translates to reasonably predictable labor costs, while the use of ORNL facilities for advanced analysis is following a cost-effective path. The reviewer noted that the project budget is neatly laid out.

Reviewer 3:

The reviewer responded insufficient and referenced comments made under Proposed Future Research. This comment is not a reflection on the investigators or their plans, but a notation that the team may need additional resources or partners if these three comments are explored. The reviewer clarified that these comments are not explored, the reviewer’s response would change to “sufficient.”

Presentation Number: mat101
Presentation Title: Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles
Principal Investigator: Xuming Su (Ford)

Presenter

David Wagner, Ford

Reviewer Sample Size

A total of four reviewers evaluated this project.

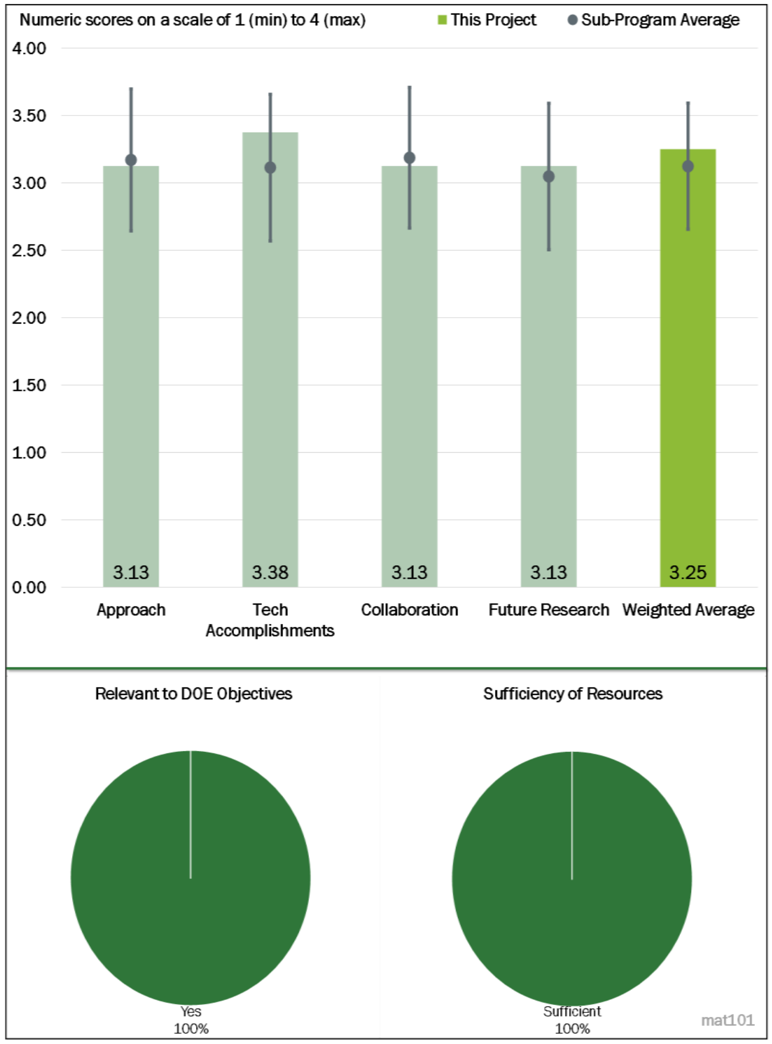

Figure 6-6 - Presentation Number: mat101 Presentation Title: Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles Principal Investigator: Xuming Su (Ford)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer found that the approach is well-designed and much accomplishment has taken place with three different material sets. The presentation noted that sheet molding compound (SMC) was the most challenging in prediction. It is known that some of the modeling tools that exist still have additional work that needs to be done on them to better predict the fiber orientation, which may been the cause of the accuracy of the prediction.

Reviewer 2:

The reviewer noted an excellent summary of a broad range of topics. What was particularly interesting for the reviewer was SMC flow modelling and the size of models and computing time required for satisfactory results. The reviewer said the project must address a “reduced” modelling approach to make such simulations palatable.

Reviewer 3:

The reviewer remarked that the effect of sizing of the CFs will have significant impact on the dynamic (crashworthiness) properties. The reviewer inquired to what extent has the modeling effort captured this, and how will the results influence the design/decision making in adopting the CFCs in this application.

Reviewer 4:

The reviewer remarked that mold flow was used at a small plaque level, which cannot be extrapolated to large three-dimensional (3-D) parts.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer noted that some good results have been reported.

Reviewer 2:

According to this reviewer, the breadth of activity and the reported results speak highly of the technical team and their accomplishments. Predictive tools for fatigue life in nCode is an important result. The reviewer suggested that extending the constant life diagrams of the UD laminates (0 and 90) as a predictive tool for a generalized off-axis laminate should be addressed and would represent an important expansion of capability. Similarly, this reviewer applauded the progress made in the application of mode I and mode II strain energy release rates for progressive failure analysis in dynamic/transient response (crash) and integrating cohesive elements in the crash modelling.

The reviewer would like to ask for additional clarity on the author's experience on using these tools for modelling mixed mode loading/failures.

The reviewer cited impressive progress made on probabilistic methods and use across the micro- and meso-scale level. The creation of a parametric representative volume element (RVE) library is an important component to accurate predictive methods. The reviewer said that it would be very helpful to demonstrate the use of these tools in prediction of additional arbitrary material/ply properties of new material systems/combinations of resins and fibers.

Reviewer 3:

The reviewer acknowledged that the project has done a lot of work, but the one thing this reviewer was struggling with was the take-away message on the accomplishments. There were several accomplishments, but the reviewer had to dig and look for them in the presentation and the reviewer did not think the message was clear on what accomplishments were against the performance metrics.

The other detail that was unclear to this reviewer is how the connection between each modeling step connected with the next and how it influenced the prediction of that step. According to the reviewer, the uncertainty propagation was not clear on how the information helped provide better predictive properties with the initial inputs providing predictive end goal outputs before tooling and molding would be committed.

Reviewer 4:

The reviewer said that integrating several software to address the complex multi-scale constituent materials and their interactions are well captured in the project. The reviewer said that additional emphasis on interface will help provide additional insight into the failure mechanisms.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that the Ford collaboration with Dow, industry partners, and the academic partners is excellent, and each partner has a demonstrated role in the project.

Reviewer 2:

The reviewer remarked that team members are solid.

Reviewer 3:

The reviewer said that from the looks of the overall progress of the project, the team had good collaboration, but the reviewer was unclear during the presentation which collaborators did which part of the work. The reviewer found the slide on the team responsibilities and the coordination was helpful.

Reviewer 4:

The reviewer noted that while the presenter briefly discussed the collaboration and partners, it was not clear where each collaborator contributed during each presented phase. The reviewer observed a well-coordinated team and suspected the collaboration was effective, just not the thrust of the presenter's prepared slides.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked the project is ending, and with excellent work on a complex problem.

Reviewer 2:

The reviewer said that the program is nearing completion and with six months remaining, the project team has outlined specific activities in the complete range of ICME technologies. The reviewer suggested that it would be helpful to define/tabulate the specific elements of each (for example, what remaining material characterization tests will be completed on the woven composite fabrics?) and how ICME will be used to predict these values, etc. Similarly, the reviewer inquired what subsystem and crash environment is planned for the simulation, and asked if this is planned to be accomplished on a previously tested part to compare analysis with a physical test.

Reviewer 3:

The reviewer found that the projected work to be done between now (July to end of December 2018) seems very ambitious. The team is looking to perform RVE, crash, uncertainty, design and optimization within the balance of the project. The reviewer was unclear how in-depth work can be done in all these areas within the given time constraint.

Reviewer 4:

The reviewer commented the drawbacks will be addressed.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer found that this program is a fine example of technologies necessary to meet DOE's lightweighting goals for 2030. The development and application of ICME tools for the predictive performance of reinforced polymers is absolutely imperative for the future use of these materials in commercial automotive applications. The reviewer remarked that a focus on cost modelling to generate a positive value proposition for weight reduction is similarly imperative. The author has done a very good job in motivating this research.

Reviewer 2:

The reviewer noted that a good theoretical understanding of the behavior of composites is a must.

Reviewer 3:

The reviewer noted that the project helps speed up the implementation of CFCs through utilizing computer-aided engineering (CAE) capability that will help evaluate the benefits prior to moving to expensive tooling and molding.

Reviewer 4:

The reviewer commented that the work focuses on lightweighting, modeling, and prediction for design into future vehicles. These technologies are within relevance to DOE objectives.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
According to the reviewer, the presenter has clearly shown specific accomplishments that meet milestones and achieve the goals stated in the program. This reviewer would simply like to see these results applied to a full-scale component along with comparison of physical results to predictions (material, structure, test and cost). The reviewer remarked resources necessary to achieve this are clearly not available for this effort.

Reviewer 2:
The reviewer said there is enough funding to deliver the stated goals.

Reviewer 3:
The reviewer commented sufficient resources were allocated for this project and milestones were completed in a timely manner.

Reviewer 4:
The reviewer said the project has adequate resources based on partners and collaborators.

Presentation Number: mat113
Presentation Title: Magnesium Corrosion Characterization and Prevention
Principal Investigator: Mike Brady (Oak Ridge National Laboratory)

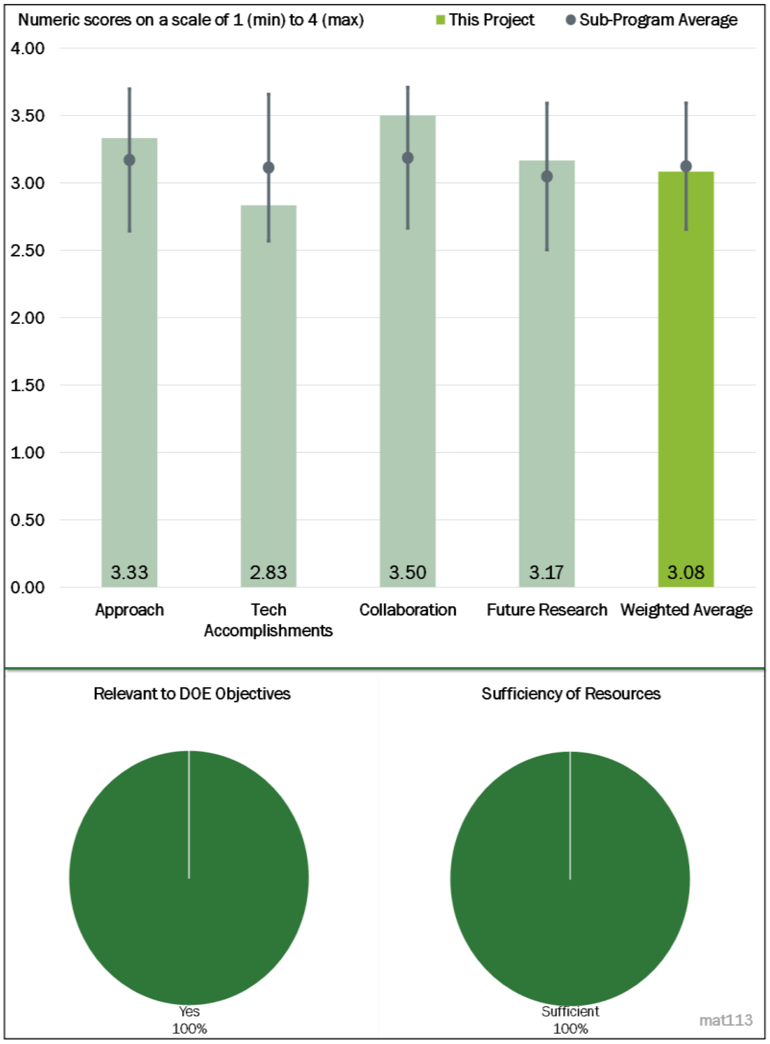

Figure 6-7 - Presentation Number: mat113 Presentation Title: Magnesium Corrosion Characterization and Prevention Principal Investigator: Mike Brady (Oak Ridge National Laboratory)

Presenter

Donovan Leonard, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer commented that the presentation did not completely explain an approach to the work, but no clear gaps can be identified. Seems like a reasonable experimental approach to generate data on corrosion behavior.

Reviewer 2:

The reviewer said that the research shows significant advancements in preventing Mg corrosion and the fundamentals of corrosion science. The researchers produced great results for the effects of various elements on surface coatings and coating thicknesses for electro-ceramic and electro-chemical coatings. The reviewer remarked the research findings on how E-coats percolate into the layers of electro-ceramic coatings and migration of Al from the alloy into the electroceramic coating were very good. The remaining studies should address the shortcomings and optimization of the coating layers.

Reviewer 3:

The reviewer noted that the corrosion performance of Mg alloys is being assessed using potentiodynamic and immersion techniques. The results indicate less of a corrosion attack on coated samples; the potential did not change after immersion. The characterization is carried out using various microscopial and electron beam instruments. The reviewer commented that this work will reveal more fundamental nature of corrosion including interfaces, coatings and diffusion of elements. The project is fundamental research and more work needs to be carried out to find evidence from older work that was carried out.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer detailed that the focus of the work is on characterizing corrosion processes using various microscopical technologies; however, the observations need to be compared with earlier work or where characterization was carried out using other instruments. The reviewer observed that the coatings selected seem to be adequate for static corrosion resistance as revealed by immersion tests.

Reviewer 2:

The reviewer remarked there seems to be a great deal of characterization that is in progress or yet to be analyzed for a project that ends in 3 months. While the reviewer appreciated the challenges with the series of continuing resolutions, it seemed like there was some more information in the back-up slides that was not discussed at all.

Reviewer 3:

The reviewer noted that the project is 70% complete and a large amount of scientific information has been gathered on the nature of various electro-chemical/ceramic coatings on Mg in just a couple of years. Although fiscal year (FY) 2018 funding was delayed, the project demonstrated good progress toward the coating characterization and obtaining in situ and ex situ data.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer noted that the project demonstrates outstanding collaboration between a national laboratory, various universities, a Mg manufacturer, and two Tier 1 materials suppliers. The expectation is that the Tier 1 suppliers will promote the findings of this research to the automobile OEMs.

Reviewer 2:

The reviewer thought it seemed that ORNL is doing the heavy lifting on this project; the wider manufacturing buy-in was not as clear.

Reviewer 3:

The reviewer observed that an international team is conducting the research, and the activities are coordinated. According to the reviewer, the relevance of the work is proved by the direct involvement on the coating selection and testing by the industry partners.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that although this project will be ending in the next few months, the PIs are planning to finish the data analysis and other programmed experiments and tests within the given timeframe. The presentation indicates that “multiple” technical papers will disseminate the findings of the research, which is good for completion of the project.

Reviewer 2:

The reviewer referenced prior comments. There seems a lot to do in the next 3 months, particularly if that includes analysis and writing. There certainly seems to be a lot of good characterization work, but it is not clear to this reviewer if that will necessarily lead to a conclusion on the cause of the different corrosion behavior. The reviewer urged the investigators to consider “good practice,” “lessons learned,” and/or "methods" papers. Development of a standard practice for evaluation of corrosion in Mg seems to be an unmet need.

Reviewer 3:

The reviewer noted that future work consists of continuation of the current characterization. However, more knowledge could be gained by comparing the results with that available from past literature.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer noted how corrosion of Mg is a significant barrier to use.

Reviewer 2:

The reviewer detailed that one of DOE's objectives is to improve the fuel efficiency of automobiles through using lightweight materials. When lightweight materials, such as Mg, are joined to other lightweight materials, the probability of some type of corrosion is high. The reviewer cited that the work done in this project helps better understand the corrosion mechanisms and the effects of industrial coatings to prevent it, thus providing a means of joining these materials in lightweight vehicles.

Reviewer 3:

The reviewer noted how corrosion is the most important problem for Mg alloy development. Understanding the mechanisms of corrosion, including diffusion of elements, hydrogen evolution, coating adhesion, and interface stability, will provide a basis for better coatings and durability. This work is providing the base by conducting characterization using most novel techniques. However, the reviewer pointed out that results need to be supported by other work.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted this 3-year project is funded at $1.15 million by DOE, or about $400,000 per year. This amount is typically sufficient for the research being conducted by the various collaborators, primarily a national laboratory and a few universities.

Reviewer 2:

The reviewer said that this project needs additional resources in the future.

Reviewer 3:

The reviewer had no comments.

Presentation Number: mat117
Presentation Title: Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications
Principal Investigator: Venkat Aitharaju (General Motors)

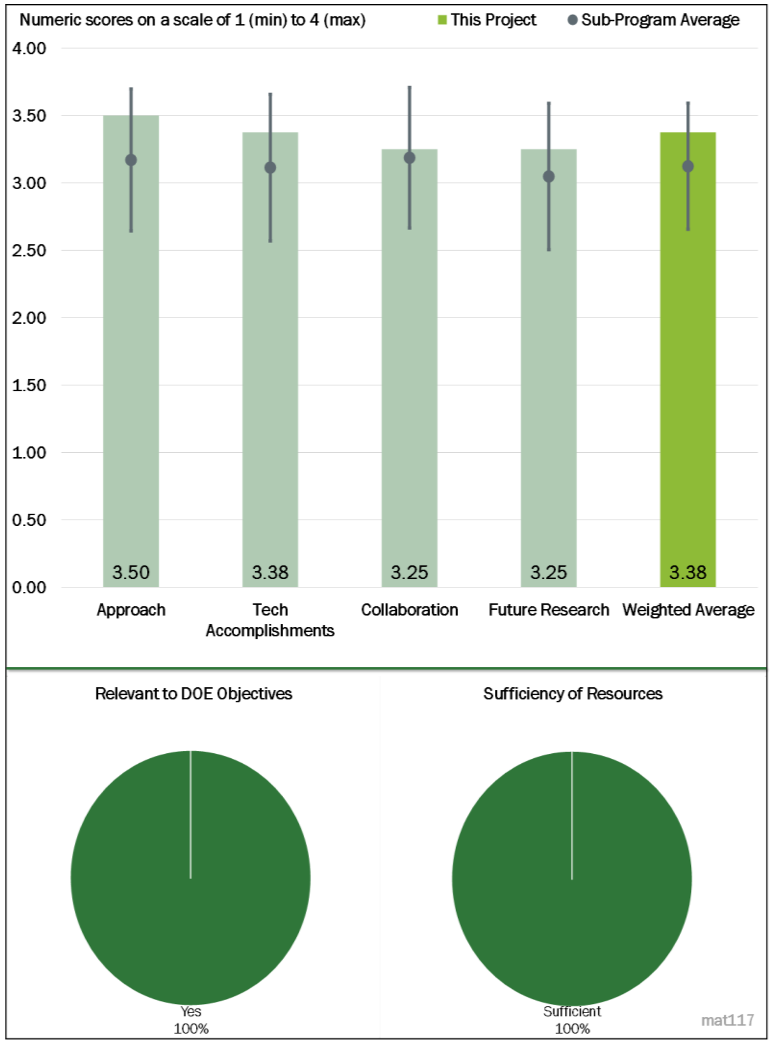

Figure 6-8 - Presentation Number: mat117 Presentation Title: Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications Principal Investigator: Venkat Aitharaju (General Motors)

Presenter

Venkat Aitharaju, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach to this complex problem is very well thought-out.

Reviewer 2:

The reviewer remarked that the approach to performing the work was very well laid-out and the team collaboration was clearly stated at the beginning of the presentation on the roles of each participant.

Reviewer 3:

The reviewer remarked the author has provided a useful flow diagram of the approach for the application of stochasitic methods in material property prediction and manufacturing. This reviewer would like to have seen more detail related to the generation of the probabilistic distribution functions that make up the inputs for both material performance and manufacturing variation to assess the likely ability to capture the full range of physics. From the variations of RVE to variance in fiber strength (Weibull), modulus, and defect density and type on the fiber, the opportunities to generate and apply multiple parameters in the pair distribution function (PDF) is rich. The author did a good job of describing, but more difficult to understand the implementation and the means of creating the PDF for each variable. The reviewer found that nonetheless, the approach is solid and will likely yield useful results that will be applicable to physical problems.

Reviewer 4:

The reviewer stated that the work progress is excellent, and the team has addressed the technical barriers in terms of manufacturing technology and stochastic materials and manufacturing simulation tools, in aiming to meet the cost metric. In general, the reviewer found that the project demonstrated feasibility, but it was unclear how the resin transfer molding (RTM) experiments translate to high-pressure RTM (HP-RTM) where the injection pressures exceed 1500 psi and over. While fast-curing resin simulation was addressed to a limited extent, the reviewer inquired how the draping characteristics influence micro-permeability, material wash, and related changes in fabric movement at high pressures.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer remarked the project is on track with all milestones being met.

Reviewer 2:
The reviewer observed excellent work on demonstrating the prediction with experimental. It would be beneficial in the future to demonstrate the progress with the percentage of correlation between predicted and experimental.

Reviewer 3:
The reviewer said that acceptable progress has been shown in both the application of stochastic methods of analysis for material/structural and manufacturing modelling. The example of a truncated pyramid to capture and model the multi-variant elements of non-crimp fabrics (NCF) draping, mold filling, cure, and resulting mechanical properties captures a tremendous breadth of activities. The reviewer observed that the presentation of methods and approaches to capture physical behavior of NCFs was comprehensive, but the reviewer was not entirely clear on the means of tying this to variance, what might be observed in stitch type, density, or other physical parameters that impacts draping. This reviewer would like to have seen more behind the means to determine the input PDF’s that constituted the modelling and the methods of solution applied, but assuming these are well-documented and ready to be integrated within a design environment, the progress is solid.

Reviewer 4:
The reviewer referenced prior comments.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer observed a well-constructed team thoughtfully assembled to include an OEM, Tier 1, and analytical support from both industry and academia. The roles of the collaborators are well-defined and the presenter referred frequently to the contributors and participants of any given activity. The reviewer exclaimed well done.

Reviewer 2:
The reviewer commented collaboration between GM, Continental Structural Plastics, ESI Group, Altair, and the University of Southern California seems to have a defined role for each partner and seems to have worked efficiently in this program.

Reviewer 3:
The reviewer commented collaborations between an OEM, other entities, and universities are excellent. The reviewer pointed out that there is no national laboratory partner, however.

Reviewer 4:
The reviewer said even though the results of the work show great progress and the team collaboration was clear on the roles in the project, the reviewer was unclear how the project was coordinated with all of the participants.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked future research is well aligned with the rest of the project.

Reviewer 2:

The reviewer observed excellent next steps for validating the models with tooling and molding to demonstrate the accuracy of the model with scaled-up experimental data.

Reviewer 3:

The reviewer commented that the team has made sufficient technical progress and demonstrated high fidelity in predictive modelling and specifically in applying the stochastic methods to warrant a move to complete a full-scale automotive assembly. The reviewer pointed out that proposed future work is an important element of demonstrating applicability and practicality in prediction of manufacturing, performance, and cost of CFRP structures. This reviewer is simply disappointed that a specific component has not been identified and presented for consideration. This omission simply makes it difficult to provide a complete assessment into the quality and completeness of planning for future proposed work. Particularly, an assessment of resource requirements and applicability. The reviewer asked if a component is not fully identified at this stage of 2018, how can a design and fully completed tool package be fabricated by the end of this year.

Reviewer 4:

The reviewer said that, in general, the proposed future research is reasonable, and that the work to be done is fairly ambitious in the given timeframe. The reviewer cited as an example comparing manufacturing process predictions for the HP-RTM and compression resin transfer modeling is an expansive study given the range of differences in process conditions. The current modeling/experiments may not be directly scalable to HP-RTM. The reviewer said it was not evident from the presentation how this gap would be addressed.

The reviewer cited as an example comparing structural predictions and experimental results for the crash performance of the assembly built for demonstration. The tooling and related experiments need more definition (or at least were not evident from the presentation briefing). The reviewer also gave as an example certification of the assembly based on the ICME tools developed in the project. The reviewer noted that this is a long lead-time issue, and asked how the team addresses it to accelerate the certification process.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that the project supports the DOE goal of weight reduction utilizing improved CAE tools for predicting part mass savings based on design and materials.

Reviewer 2:

The reviewer said that this work well-supports relevance to DOE’s lightweighting goals. Clearly, capturing through application of stochastic methods the well-understood variance observed in the materials and methods of manufacture is vital to successful use of these materials in a commercial automotive structure. The reviewer remarked that the author has successfully motivated this work and demonstrated relevance through successful correlation of the models to physical data generated through the program.

Reviewer 3:

The reviewer commented CF-based composites are one of the effective lightweighting strategies in the DOE Materials portfolio.

Reviewer 4:

The reviewer found that the work is directly relevant to DOE objectives in lightweighting and a multi-materials ICME approach to achieving optimized designs for future vehicles.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that the progress and results of the work presented to date demonstrate that resources have been sufficient to meet milestones. While the work is ambitious, the presenter has clearly demonstrated the utility of the methods employed and the contribution of the collaborators appears consistent with the level of funding.

The reviewer was not clear that resources for the work remaining are sufficient. Because the author identified no specific automotive assembly, it is impossible to assess the costs required to complete the work and relevance (or value) that will result for the remaining funds available to the project.

Reviewer 2:

The reviewer remarked resources are sufficient.

Reviewer 3:

The reviewer observed excellent progress with milestones and the funding that was used.

Reviewer 4:

The reviewer said that the team is well-equipped to undertake this work.

Presentation Number: mat118
Presentation Title: Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly
Principal Investigator: Srikanth Pilla (Clemson University)

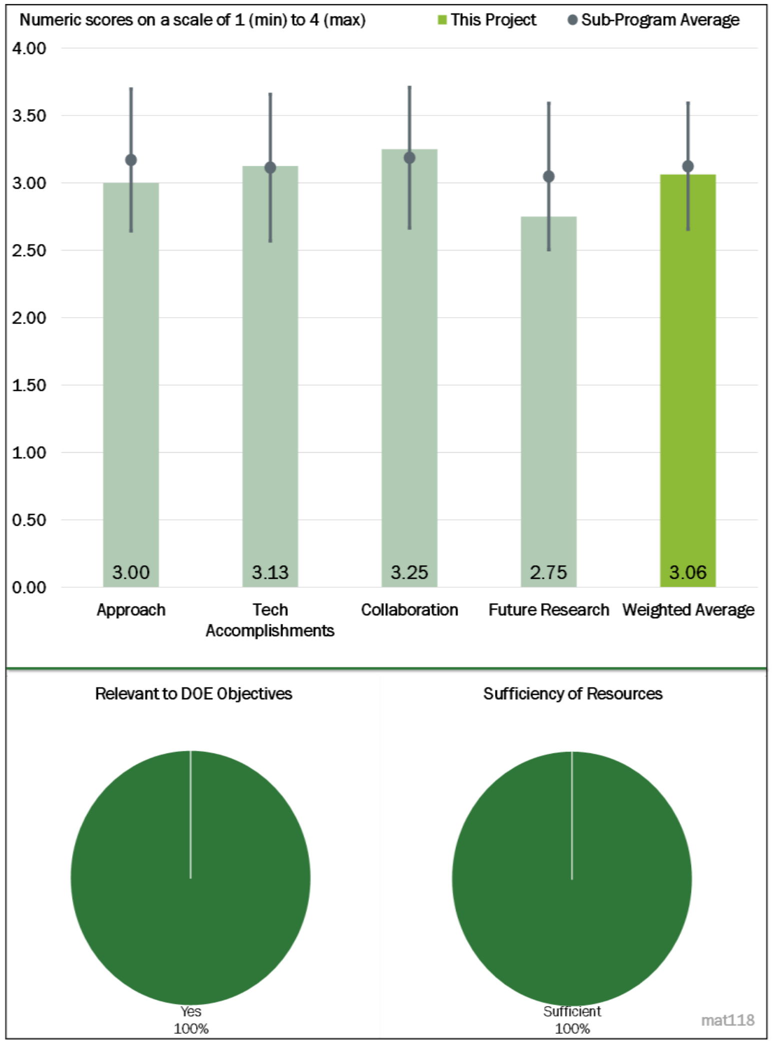

Figure 6-9 - Presentation Number: mat118 Presentation Title: Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly Principal Investigator: Srikanth Pilla (Clemson University)

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer commented that the approach to perform the work was good. As the cost of the door assembly with CFCs is one of the prime objectives, the cost models, selection of material, and manufacturing process should have worked out in the first few phases of the project.

Reviewer 2:

The reviewer acknowledged that this is a challenging problem that the Clemson team has an effective plan to address. The team is making good progress with a sound approach, but it is not clear to the reviewer that the targets will be met. The reviewer noted that the targets were stiff.

Reviewer 3:

The reviewer detailed that the project started with seven concept designs and down-selected to two. Finite element analysis was applied to each concept, and the team used optimization for gauge thickness. The reviewer found that more comprehensive optimization would be achieved by integrating material choices, functional requirements, and cost into a single CAE optimization analysis.

Reviewer 4:

The reviewer said that the project is generally on track. There are several technical barriers—particularly in that the weight optimization is done on a structural parts level—while the overall weight is impacted by the system level. Several traditional components are going to be used in the weight optimized composite structure. The reviewer recommended that an overall weight scenario including all sub-components (existing and new) should be accounted for.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked excellent progress towards meeting the targets. As noted earlier, the targets were challenging.

Reviewer 2:

The reviewer said that the project met all milestones.

Reviewer 3:

The reviewer said that it looks like the composite design meet the static requirements with mass savings of 60% compared to the baseline steel case (6.18 Kg with projected weight savings of 60%). The reviewer was unsure why the quasi-static Federal Motor Vehicle Safety Standard 214 analysis case was run with 12.2 Kg closer to steel mass of 15.45 Kg. The reviewer said the analysis should have started with 6.18 frame mass and mass needs to be increased only to meet the federal requirements rather than the baseline steel door.

Reviewer 4:

The reviewer referenced prior comments and suggested developing an understanding to capture the crashworthiness expected with the redesigned features and their interactions with respect to the traditional components such as window modules, etc. The reviewer inquired if by excessive lightweighting, these interactions will adversely influence impact performance.

The reviewer also asked what the influence is on cost metrics on multi-process design, such as thermoforming, long fiber thermoplastic and related processes and assemblies. Further, the reviewer expressed interest in the projected infrastructure to enable adoption of these designs compared to existing sheet metal processes and other thermoplastic composite options.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed a very good team led by Clemson and with the University of Delaware, Honda, and Corning as participants.

Reviewer 2:

The reviewer said that the partners are working closely and great progress has been made.

Reviewer 3:

The reviewer commented that the collaboration between Clemson, Delaware, Corning, and Honda seems to be going well. Each partner has a role in the project. The reviewer said the presentation identified a host of material suppliers—perhaps their roles and engagement will be more tangible in the future work.

Reviewer 4:

The reviewer noted that manufacturing of the composite door is critical for the project. The reviewer inquired if this assignment was contracted out, or if any partner is taking care of this.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that the plans are well laid-out in alignment with the goals of the project.

Reviewer 2:
The reviewer remarked that there is a lot to be done in this project to assess the confidence in the design and performance. The identified pathways for dynamic simulations; manufacturing simulations and tooling design; and mass production plan and cost model refinement are all necessary to evaluate the feasibility of the downselected design.

Reviewer 3:
The reviewer stated that the proposed research works are necessary for completion of the project. A potentially better design could be achieved by an optimization that considers the impact of local variation of material properties. The local material properties are predicted by simulations of manufacturing processes, which the reviewer noted are planned future work.

Reviewer 4:
The reviewer commented that proposed future work seems very challenging in regards to dynamic simulations, and manufacturing simulations. Given these challenges, the reviewer was not sure why the proposed analysis for a plant layout is needed for this project.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer remarked that the project is a perfect example of lightweighting vehicles using composites.

Reviewer 2:
The reviewer commented the project directly supports DOE goals of lightweighting while maintaining the vehicle performance.

Reviewer 3:
The reviewer found that the relevance to DOE objectives is appropriate in terms of lighweighting and multi-material optimized design for vehicle components—an automotive door in this case.

Reviewer 4:
The reviewer said that this project support the overall DOE project objectives of automobile lightweighting and thus achieving improved fuel economy and reduced emissions.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented resources are sufficient.

Reviewer 2:
The reviewer said the team has adequate resources to conduct the work.

Reviewer 3:
The reviewer said resources seem sufficient. The reviewer pointed out the objective of the project is quite ambitious, but the project got help by involving a number of graduate students.

Reviewer 4:
The reviewer suggested that an OEM partner may be needed to provide improved support for simulations given the existing challenges in the future work.

Presentation Number: mat119
Presentation Title: Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration
Principal Investigator: Nate Gravelle (TPI)

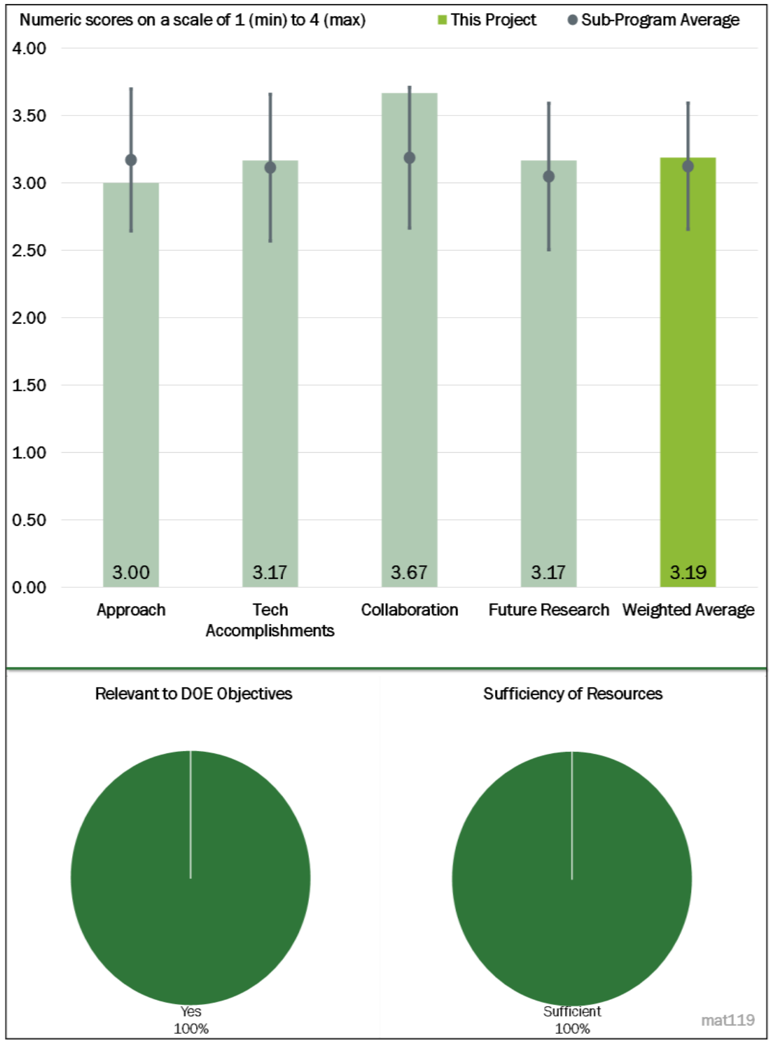

Figure 6-10 - Presentation Number: mat119 Presentation Title: Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration Principal Investigator: Nate Gravelle (TPI)

Presenter
Nate Gravelle, TPI

Reviewer Sample Size
A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer said that the overall technical barriers are being addressed very well. The reviewer was unclear how the materials were being characterized for HP-RTM where the resin is injected at 1,500 psi and above. The reviewer asked how the characterization work will translate to the HP-RTM process.

Reviewer 2:
The reviewer remarked this presentation says little about the approach, and there is little information on the molding process, the subcomponent fabrication, or the subcomponent evaluation. The reviewer remarked that there are few details about the CAE analysis; the local material properties, for example, are completely missing from this presentation. There is a picture of dynamic CAE for side pole impact, but no information. The reviewer noted that while there was a go/no-go gate in October 2017 based on the demo manufacturing rate, there is zero information in this review presentation. The reviewer said there is no discussion of the critical performance measures for the design. The reviewer had expected to see metrics or targets for stiffness, strength, impact, fatigue, corrosion, sealing, noise transmission, appearance/smoothness, dent and ding resistance, palm dimpling/oil canning, and door closing sound quality. The reviewer said that none of these performance requirements are addressed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer remarked that some input was included in Q.2.

Reviewer 2:
The reviewer said that there is little information on the technical accomplishments other than the CAE design. The reviewer was unclear if the load case of dent and ding damage to the outer panel was addressed in the CAE. The lack of information on the material properties is disappointing. The reviewer said there is little information on the materials or the processing conditions. The reviewer was perplexed that the design fails to meet the torsional rigidity requirement, yet is deemed okay. This reviewer expected to see information on the manufacturing process to yield the cycle time that is stated to be a major objective of the project. Additionally, there is little information on the testing to prove the design and correlate the CAE. With the failure to meet torsional stiffness, the reviewer expected failures in the wind, noise, and water leak tests for this design. Also, the Class A surface finish is a requirement for the door, and the reviewer said that this project ignores this performance requirement.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer said that the collaborating team of TPI Composites with Hexion, Saertex, Creative Foam, Alpex, Krauss Maffei, and the University of Delaware is excellent.

Reviewer 2:
The reviewer stated that while the listed subcontractors are appropriate for this project, the collaboration and cooperation are not clearly defined. For next year, the reviewer recommended that the project please include a matrix of when different groups meet and cooperate on aspects of the project. The reviewer acknowledged this is likely okay, but there is little evidence in the presentation.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the future work in terms of tool build, crash modeling of the intrusion beam, and using low-cost CF are appropriate and much-needed for the next steps.

Reviewer 2:
The reviewer said that because no design verification tests are defined, it is difficult to comment on the proposed future work. The reviewer would have expected to see the full verification test plan at this point in the project. Hopefully, there will be full vehicle testing for water leaks, wind noise, corrosion, moving barrier side impact, and side pole impact. The reviewer said that hopefully, there will be component testing for dent and ding, palm loading as well as slam durability, overload open, and other component tests. The reviewer said that future work stated on Slides 22-25 appear vague. The reviewer inquired what the project team will do to reduce the mass of the door internals that comprise more than half the door mass.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer said that the project addresses the cost and weight reduction metrics through materials and process innovations.

Reviewer 2:
The reviewer remarked this projects supports the DOE goals of vehicle mass reduction and increased use of CFC materials.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked a total of $5.9 million are sufficient resources to produce and test a prototype side door. The time is sufficient to complete the design, tooling, manufacturing, assembly, and testing for a driver's door.

Reviewer 2:

The reviewer commented that the team has excellent resources.

Presentation Number: mat122
Presentation Title: Low-Cost Carbon Fiber Research Using Close Proximity Electromagnetic Carbonization (CPEC)
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

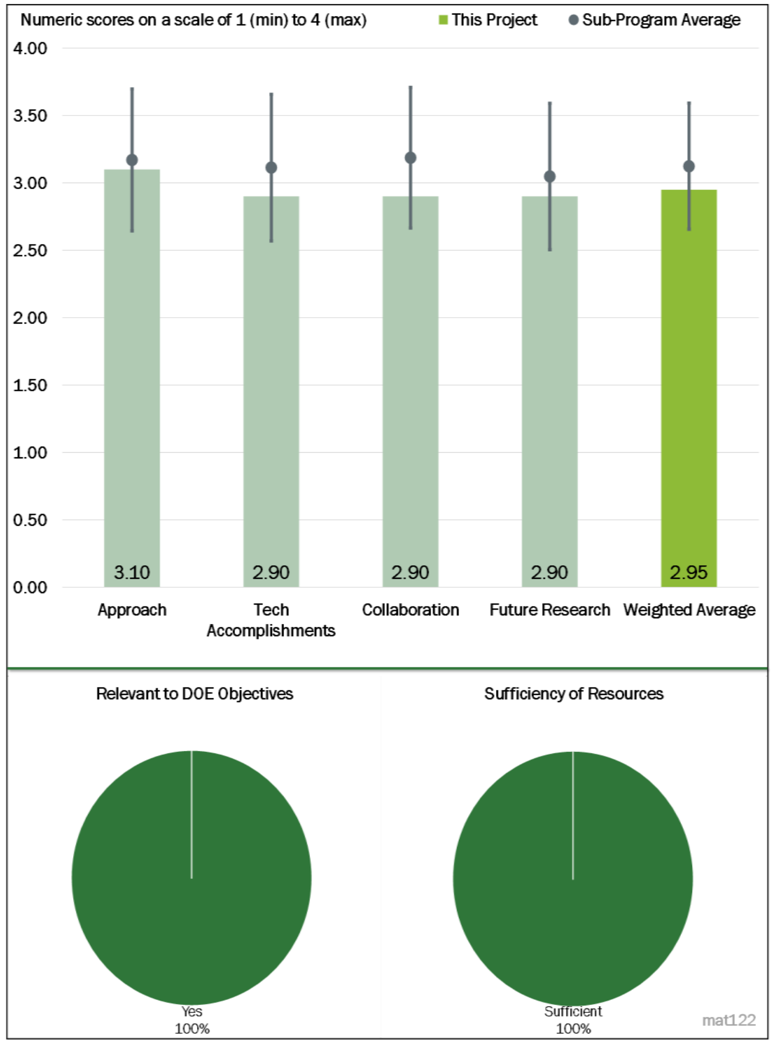

Figure 6-11 - Presentation Number: mat122 Presentation Title: Low-Cost Carbon Fiber Research Using Close Proximity Electromagnetic Carbonization (CPEC) Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that this is an excellent project. The approach is sound with dielectric heating to heat the fiber rather than the gas surrounding the fiber. This should reduce the energy required and hence reduce the cost.

Reviewer 2:

The reviewer commented that it is important to reduce energy consumption

Reviewer 3:

The reviewer stated that the project has made good headway in its goal to reduce unit energy consumption of low-temperature carbonization (LTC) stage (kWh/kg) by approximately 50% or 5% of the cost reduction on the CF overall manufacturing process. The reviewer found that the barriers are to some extent addressed—although there is a long way to go in this project.

Reviewer 4:

The idea and approach to replace thermal methods (i.e., furnaces) of LTC with methods of directed energy is important and useful. What is more concerning to this reviewer is certain assumptions related to cost and performance targets. Existing CF materials already approach the $7/lb upper cost target (at volume) suggested by the presenter. The reviewer pointed out that when this fact is combined with performance goals of 250ksi and 25 MSI (strength and modulus), the reviewer became further concerned about the research goals. Commercial/industrial polyacrylonitrile fiber today exceeds 500 KSI strength and 30 MSI modulus, making the relative value in terms of $/MSII (strength or modulus) lower than the goals set by the presenter.

The reviewer said that similarly, the goal set to reduce energy consumption by 50% in the LTC stage seems underwhelming in the total manufacturing cost model as presented by the author (i.e., 5% of total manufacturing cost). Nonetheless, a 50% reduction in any specific process is important, non-trivial and should be pursued. The reviewer is simply left wondering if the technology can be extended to other elements of CF production for greater impact.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the accomplishments from the Close Proximity Electromagnetic Carbonization (CPEC)-3 furnace are excellent. The reviewer wished the standard deviations were less. The design for CPEC-4 is complete and the procurement is underway. The reviewer said that the mix of modeling and experimental accomplishments is very strong.

Reviewer 2:

The reviewer said that the team has presented a significant amount of work accomplished, particularly in the design and fabrication of three versions of LTC prototypes. This work has demonstrated the feasibility of the technology and should also be recognized. The reviewer noted that a table of results for both fiber strength and modulus was presented and partial victory was claimed regarding programmatic goals; however, scatter in the strength results of even the most promising trial was so high as to yield unusable materials in a practical application. It is not clear to this reviewer why the technical leader would progress to scaling the process (i.e., build CPEC-4) without fully identifying and mitigating the sources of this variation and demonstrating a significant reduction in fiber variation.

The reviewer also pointed out that there was no data presented regarding energy requirements for the LTC and thus no direct correlation to the most important goal, identifying opportunities for both cost and energy reduction. The project goals and relevance will be significantly enhanced by incorporating a comprehensive cost model to reflect increase in line capacity from shorter residence time as well as the impact on energy reduction and change in CAPEX expected. The reviewer asked how these factors will affect total cost. It would be helpful for the project team to expound on the use of computer aided design and the usefulness of the results to improve the design of the CPEC-4. The reviewer was not clear how the modelling is used in the machine or process design.

Reviewer 3:

The reviewer commented that more work is needed to improve mechanical properties and reduce scatter.

Reviewer 4:

The reviewer remarked that the infrastructure to scale-up this process and energy implications of scaling up for the electromagnetic (EM) field was not clear. The reviewer asked how the cost metric will be influenced by scaling up the EM generators. The reviewer asked how attractive this process will be when alternate processes are providing fiber in the 350-400 ksi and 35+ Msi range, and will the EM process be less expensive than thermal processes to obtain low-cost CF.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer commented that ORNL collaboration with RMX Technologies, 4M Carbon Fiber Corp., and Litzler is very good and each partner has a specific role.

Reviewer 2:

According to the reviewer, the team is focused on this targeted effort for carbonization. The plasma experts, the oven manufacturer, and a CF supplier are the proper team for this project. The reviewer suggested showing the frequency of Web-based meetings and face-to-face meetings to clearly describe the collaborations.

Reviewer 3:

The reviewer said that industrial partners appear adequate to support this project. More discussion regarding the scaling of the equipment and the involvement of the collaborators meeting certain CAPEX and capacity requirements for commercialization would be helpful to assess the probability of success. The reviewer said that the author did not provide detail regarding the contribution of each participant in the different phases of technical progress.

Reviewer 4:

The reviewer noted that ORNL has the major role.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that a lot of the proposed research hinges on the CPEC-4 furnace build and optimization—this will provide the investigators all the data for their next steps. The reviewer found that this is a reasonable goal.

Reviewer 2:

The reviewer found that the future work proposal is clear and concise. What remains missing is the technical means to overcome the variance seen in mechanical strength and the challenges associated with scaling from a single tow to multi-tow LTC processing. The reviewer remarked that the author has not provided any detail regarding the baseline throughput or energy requirements for conventional furnace processing of the LTC stage of carbonization. It would be helpful to outline the details of measurement and comparison. The reviewer said that it would also be helpful for the author to present or outline the steps of economic evaluation. The reviewer asked what the baseline assumptions and costs are.

Reviewer 3:

The reviewer commented that the future work addresses all the challenges now foreseen in the project. The scale-up will likely produce other, currently unforeseen challenges the team will address. The reviewer recommended that the controls to tune the electric field to carbonize the fiber and thus reduce the standard deviation of the final properties must be addressed.

Reviewer 4:

The reviewer commented to address the shortcomings of the current results.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that CF cost reduction is very important.

Reviewer 2:

The reviewer said that this project addresses the cost of CF by focusing efforts on reducing the energy for the carbonization.

Reviewer 3:

The reviewer commented that the current project supports the overall goal to expand the use of lightweighting materials by 2030 through a reduction in the fundamental cost and embodied energy in CF manufacturing. The reviewer pointed out that the only question is whether the funds expended are returned through the economic impact, which has not been fully qualified. That is the most significant flaw contained in this project.

Reviewer 4:

The reviewer noted that the project deals with alternate ways of producing CF and may have an impact on the U.S. manufacturing base provided the team is successful in lowering cost at the relevant scale.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the funding is sufficient.

Reviewer 2:

The reviewer said that the team has adequate resources and expertise to carry out the work.

Reviewer 3:

The reviewer said that resources are sufficient for the project.

Reviewer 4:

The reviewer remarked that there appears to be sufficient funding. The specifics associated with the building of CPEC-4 makes it very difficult to assess, but the author did not express concerns regarding the costs associated with scaling the CPEC-3 and fabricating the hardware to complete the 8-tow scale-up LTC. The reviewer said that it is difficult to assess, given the lack of attention spent on modelling the economics of the process, whether resources are sufficient to complete the techno-economic modelling necessary to fully assess project impact and likelihood of commercialization.

Presentation Number: mat124
Presentation Title: Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber for Lightweight Vehicles
Principal Investigator: Xiadong Li (University of Virginia)

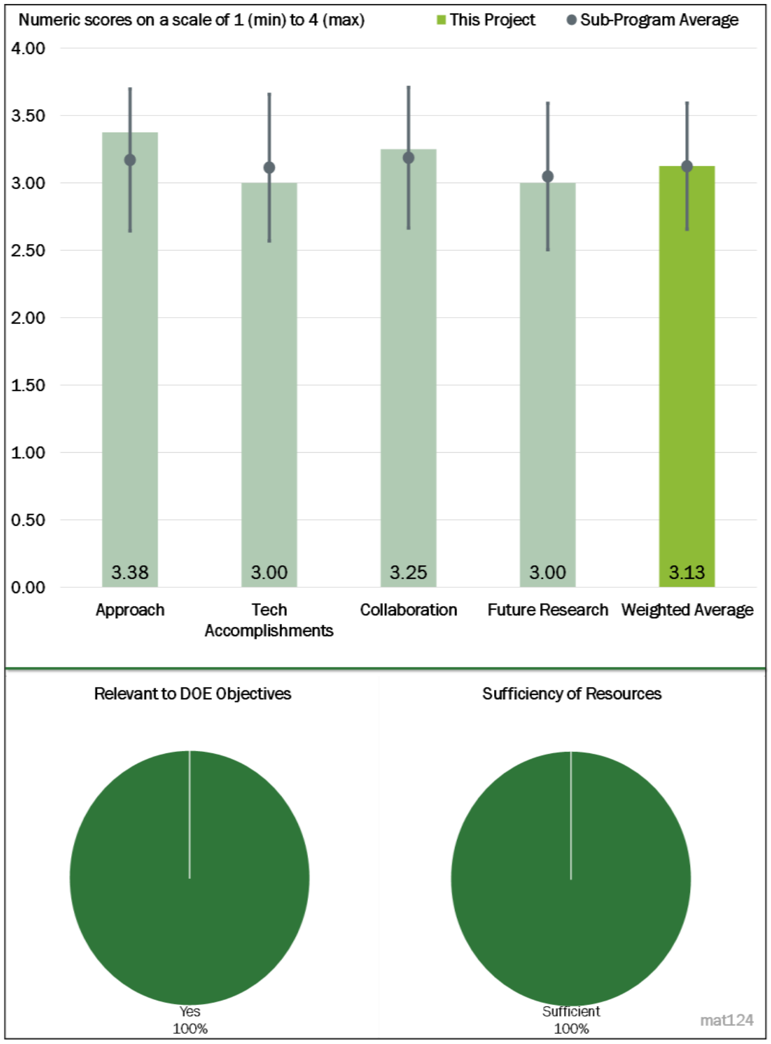

Figure 6-12 - Presentation Number: mat124 Presentation Title: Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber for Lightweight Vehicles Principal Investigator: Xiadong Li (University of Virginia)

Presenter

Xiadong Li, University of Virginia

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the team has an attractive ICME approach to develop and deploy CF precursors with improved performance. This is an early-stage project that started this FY so the team did not have a lot to report.

Reviewer 2:

The reviewer said that the Approach to step through the process to see where efficiencies can be found is laudable. This should help identify opportunities for cost reductions. The reviewer said that using ICME framework to identify lower cost precursors to reduce precursor cost, and hopefully reduce the energy required to produce the final CF, is appropriate. The reviewer identified as one issue moving forward the inhetrogeneity of the precursor. This is what doomed previous efforts on lignin precursors. Within the research, the reviewer stressed that care must be taken to quantify the amount of imperfections tolerated in each step of the process.

Reviewer 3:

The reviewer said that the approach outlined in the reviewed presentation lacks specificity regarding the modelling and simulation methods as well as the specific testing proposed. The back-up slides expose a bit more detail, but relatively important elements related to embedded flaws in the atomic structure and whether stochastic in nature or a result of precursor chemical makeup and contamination would (notionally) appear to be an important consideration to bake into a model/simulation.

The reviewer remarked given that cost is such an important element (or constraint) in determining project success or failure, there is a general lack of attention to modelling, or including in the framework the fundamental elements of cost modelling. This reviewer would like to see, at the very least, identification of the cost elements and the methods this research will use to model these costs in parallel to modelling the performance. The reviewer noted how the team pointed out the challenge of costing given the chasm between lab scale an industrial scale, but according to the reviewer that is not suitable justification for not addressing the specifics of a cost model.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer pointed out that this is an early stage project as mentioned so the team has limited progress at this time.

Reviewer 2:

The reviewer remarked the initial Technical Accomplishments are promising and on track. In the molecular dynamics work, the reviewer hoped that the researchers include imperfections in the precursor and propagate the effects of those imperfections throughout the analyses. The reviewer commented he initial work only addresses “perfect” chemistry.

Reviewer 3:

This reviewer is concerned that specific technical progress related to the milestones is thin. Little was presented either in the experimental or simulation efforts that will be required to meet Milestone 2 and Milestone 3. The reviewer said it would be helpful to have been exposed to some of the specific modelling approaches used and the chemistry assumed in setting up the simulation. The reviewer thought it would be much easier to assess the progress and the likelihood of success for these two milestones. Additionally, Milestone 4, while referenced to be 80% complete, lacked detail in terms of reporting on the methods used to optimize wet/melt spinning processes and the results of this optimization.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer commented that this is a strong team led by a university, but with additional national laboratory and industry members as part of the team.

Reviewer 2:

The reviewer said that this is a well-thought out project team with adequately identified roles. The reviewer would like to better understand the role of Oshkosh, particularly in supporting the requirements, testing, and application of the results. Their understanding of product cost versus performance would appear to be critical for establishing metrics for success.

The reviewer noted that the presentation did not identify or present specifics regarding rhythm or team interaction, meeting, teleconferences, and quarterly reviews. This would be helpful to include given the breadth of the project team and the roles each must play.

Reviewer 3:

The reviewer remarked that monthly meetings are barely enough to keep this complex project running smoothly. Especially during this critical first year, the reviewer recommended that the group needs more frequent contact to form up as a high functioning team. The reviewer encouraged weekly web-based meetings and monthly face-to-face meetings for the next year.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that there is scarce detail related to work planned for the balance of this FY or the two remaining. Given the large resources provided by the federal government ($3 million), this reviewer would expect more detail regarding the direction of the work plan. Particularly, given the overarching goal of developing models and simulations that will lead to the use of fundamentally lower-cost precursors to yield CF products below $5/lb. The reviewer asked what additional equipment requirements will be put in place, if any, to work on conversion of new precursors. The reviewer also asked what screening the team might use to determine the potential for alternative precursors to meet cost performance, mechanical performance, and scalability.

Reviewer 2:

The reviewer cited a couple of questions to ask. The reviewer asked if models for oxidation/carbonization, etc., are equally difficult/easy. The reviewer said that some sort of gap analysis will be useful to go with this ICME project. The reviewer cited that the team used ReaxFF simulations to quantify bond energies. The reviewer asked if it is clear that benefits at the bond level translate to the fiber level and if so, is there literature supporting that.

Reviewer 3:

The reviewer remarked that proposed future work is appropriate. However, the description in the presentation is rather vague on what “alternative precursors” will be considered. The reviewer noted that Technical Accomplishments showcased “Exploration of alternative precursors and production methods;” however, no specific information was given other than nylon will be investigated.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that efforts to investigate alternative precursors and all the processing steps are key to reducing the cost of producing CF.

Reviewer 2:

The reviewer pointed out that CF-based composites is one of the key areas in the lightweight materials portfolio.

Reviewer 3:

The reviewer remarked that the drive toward lightweighting (as well as all the benefits gained from non-metallic solutions for automotive and transportation systems) is predicated upon creating fundamentally low-cost, high specific property materials. In particular, CF has a fundamentally low-cost atomic make-up (C...pretty common material) as well as fundamentally high specific properties (both modulus and strength) when structured properly. The reviewer remarked that this program addresses the need to develop a toolbox with which to evaluate the potential of a given precursor to meet aggressive cost and performance goals. Such capability is critical to achieve this end. The reviewer found that relevance will be positively impacted if a technically sound simulation/method of costing the scaled high-performing materials is demonstrated. The reviewer recommended there should be more emphasis placed up this component of the work.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked resources are sufficient.

Reviewer 2:

The reviewer said that the $4.4 million planned and the three-year timeline is sufficient to complete this work. While the presentation was not specific regarding equipment, computing or software required to be purchased, it is this reviewer’s belief that the financial resources are adequate for this effort.

Reviewer 3:

The reviewer said that at this point, the resources appear sufficient to complete this project in the time remaining. The access to laboratories at the University of Virginia, Penn State, ORNL, and Solvay should be sufficient to get all the work accomplished.

Presentation Number: mat125
Presentation Title: Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber
Principal Investigator: Donald Collins (Western Research Institute)

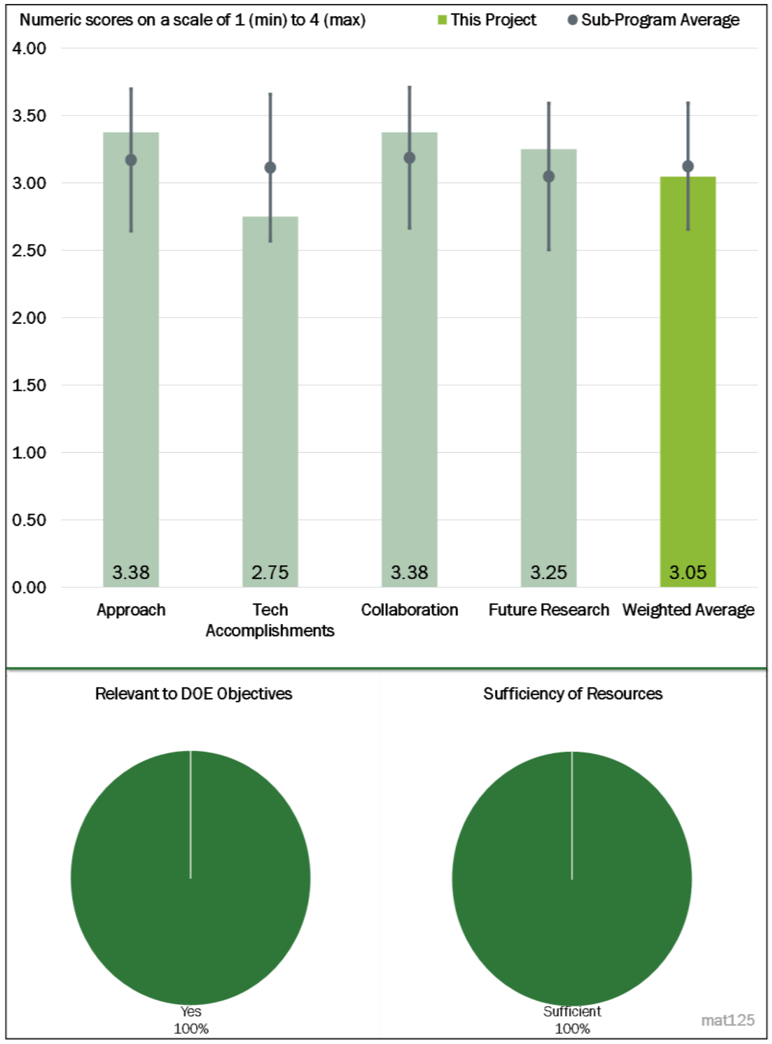

Figure 6-13 - Presentation Number: mat125 Presentation Title: Integrated Computational Materials Engineering (ICME) Predictive Tools for Low-Cost Carbon Fiber Principal Investigator: Donald Collins (Western Research Institute)'

Presenter

Jeramie Adams, Western Research Institute

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer observed a good solid project approach for this effort. The project started this FY and the team did not have a lot to report in terms of results.

Reviewer 2:

The reviewer remarked that the Approach appears sufficient to address the project. The evaluation of multiple materials should improve the chances for low-cost CF. The reviewer recommended that the project team please play close attention to the tolerance for impurities and/or unwanted phases/defects/impurities. Also, be sure to address the mechanical (tensioning and roller controls) as well as the thermochemical processing steps.

Reviewer 3:

The reviewer recommended that feedstock heterogeneity has to be addressed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed a good start to a difficult project, and the project is poised for good progress. The details of the molecules are critical for successfully getting to CF. The reviewer noted that issues of impurities and the robustness of each process to impurities are critical.

Reviewer 2:
The reviewer pointed out that the project has just started.

Reviewer 3:
The reviewer emphasized that this is a new project so no significant technical accomplishments were provided at this time.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer said good team with a number of key partners that will allow this project a good chance of success.

Reviewer 2:
The reviewer said the participants are well-positioned for this project to be successful. The reviewer suggested showing the interactions and the meeting frequency. The reviewer said that with a large, geographically separated team, the number and frequency of meetings, and particularly face-to-face meetings, is critical.

Reviewer 3:
The reviewer remarked many experts that can help.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented an outstanding plan for future research was well-presented.

Reviewer 2:
The reviewer remarked plans are good; the implementation has to happen

Reviewer 3:
The reviewer commented that the proposed future work is good. However, according to the reviewer, there are not sufficient details on the measurements and tracking of impurities in each of the feed streams. Also, there is no mention of the mechanical processes steps such as tensioning.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer agreed that these efforts to identify opportunities for lower-cost CFCs certainly are relevant to the DOE goals for energy reduction through vehicle lightweighting.

Reviewer 2:
The reviewer said that CF is a key material in the lightweighting portfolio.

Reviewer 3:
The reviewer noted that cost reduction and sustainability are important.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer remarked the resources appear to be sufficient for this project to be successful.

Reviewer 2:
The reviewer said that resources are sufficient

Reviewer 3:
The reviewer commented that resources are sufficient at this time.

Presentation Number: mat126
Presentation Title: Room-Temperature Stamping of High-Strength Aluminum Alloys
Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

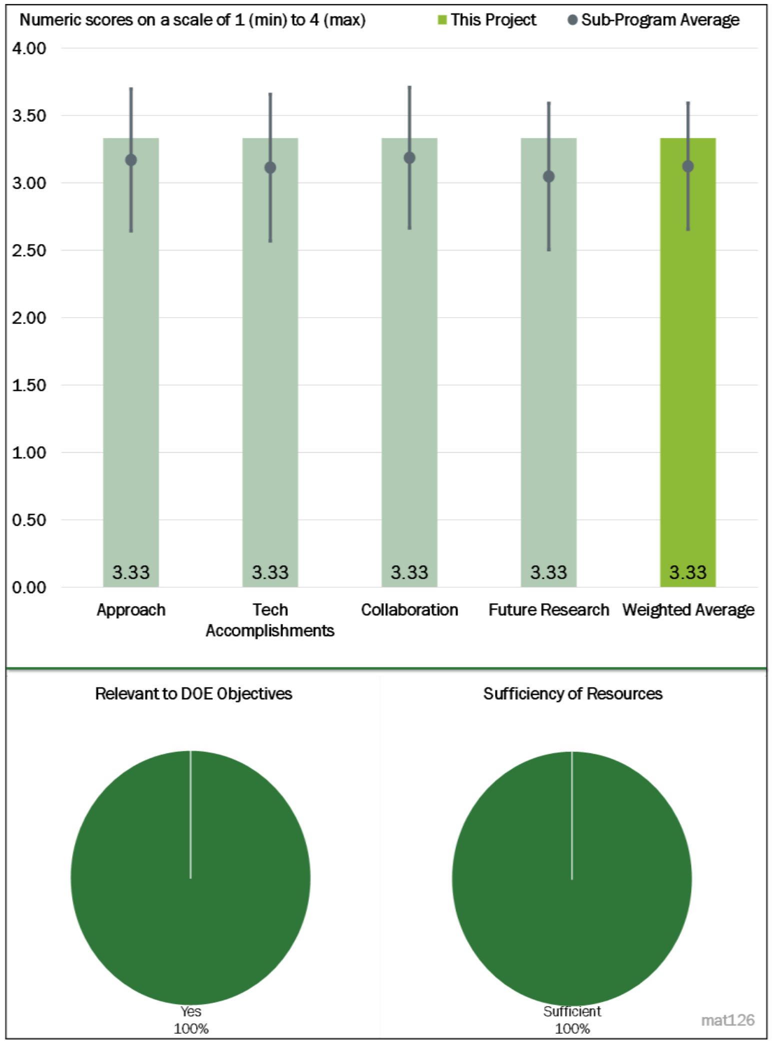

Figure 6-14 - Presentation Number: mat126 Presentation Title: Room-Temperature Stamping of High-Strength Aluminum Alloys Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Presenter
Aashish Rohatgi, Pacific Northwest National Laboratory

Reviewer Sample Size
A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer detailed the barriers described are to enable stamping and formability, at room temperature, of high-strength Al for structural components used in automotive applications. The project evaluates thermo-mechanical treatments and uses constitutive relations and simulations to verify that the component can be stamped at room temperature through integration of microstructure and mechanical property models. The reviewer said the experiments on the material coupled with the modeling and stamping simulations before fabricating a prototype component for full-scale testing is a sound engineering approach for addressing a difficult problem with Al alloys.

Reviewer 2:
The reviewer said that the approach of the work is generally good. The reviewer pointed out there is little information on the work that was carried out to fulfil the go/no-go gate one decision point. The reviewer asked if there are proprietary information issues associated with divulging the analyses that was carried out. The analyses seem to be important enough to be made a decision point. The reviewer thought that a presentation of projected weight reduction by component would be helpful. The reviewer said there are no targets for mechanical strength for the room-temperature formed components. The reviewer said the project team implied that they will meet or exceed the performance of the HSS they will replace, but the numerical targets should have been clearly stated still, along with other important targets.

The reviewer has a few concerns. The reviewer asked what acceptable limits are on the strain of the material/components after it/they has/have been formed at room temperature. The reviewer asked how high-strain areas are expected to perform during service at said strains (presuming that post forming heat treatments are to be eliminated to keep component costs as low as possible). The reviewer asked for instance are resultant strains/elongation just short of the material tearing acceptable (as long as no visible tearing takes place). The reviewer inquired, apart from gathering stress strain curves, what other mechanical testing will be carried out to qualify the process and components, and how will the performance of the Al components be compared with the baseline material (the HSS). The reviewer understood that no stress-corrosion cracking evaluation will take place. It appeared the PIs are heavily reliant on modeling and simulations. While modeling and simulations are essential to success, it is the opinion of the reviewer that some sort of validation needs to take place to make sure the results are accurate and can be broadly applied across the numerous components to be replaced. The reviewer said that some testing may also be prudent for the purpose of validating the results.

Reviewer 3:

The reviewer said that the formability of Al alloy A7075 at room temperature is being investigated. This high-strength alloy exhibits very limited formability and this will be a challenge. The reviewer noted that currently, this alloy is formed at higher temperatures, in the range of 225°C-250°C. The approach of using actual parts is good, but common engineering tests need to be carried out. The reviewer also pointed out that the information from current literature needs to be presented. The reviewer said what will be the difference in technology to ensure crack-free forming at low temperatures.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the results for the characterization of the mechanical properties and the friction effects during formability of the selected alloy show excellent agreement with the LS-Dyna modeling. This should improve the level of success for the next phase of component testing and prototype fabrication.

Reviewer 2:

The reviewer said that accomplishments could have been described in a bit more detail, especially in the back-up slides for the attention of the reviewers only if there was not enough time to do it in open forum. The PIs seem to be underspent by a large margin, so this bodes well for them when comparing the current accomplishments with the resources remaining to carry out the work. The reviewer remarked that the Gate 1 decision point seems to have been passed successfully. However a Gantt chart showing progress by task (as described on Slide 5) would have been more useful to the reviewer in assessing progress against tasks.

Reviewer 3:

The reviewer pointed out that only characterization of the base material is completed by developing the forming limit diagram (FLD). This is good, but actual testing needs to be carried out. Also, the project team made efforts to develop models to help future design efforts.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that the project demonstrates excellent collaboration between two national laboratories, a Tier 1 supplier, and an automotive OEM. At this advanced stage of development, involvement by academia would not be beneficial.

Reviewer 2:

The reviewer pointed out that General Motors has no Future tasks (Slide 12). The reviewer inquired if GM has accomplished all their tasks in this project (apart from reviewing the project progress and final report). The reviewer noted that Magna seems to have a central role in the project, which is encouraging. ORNL has no other role in the future as well. The reviewer noted that it was stated that Rich Davies left PNNL for ORNL, so a question the reviewer posed is whether ORNL should be listed as a collaborator, unless Rich still has a central or significant role in the project.

Reviewer 3:
The reviewer detailed that the partners include an OEM and one Tier 1 supplier; the material supplier is not included but this may not be a problem, as many commercial suppliers are available. The reviewer suggested that it would add strength if material specifications and more knowledge on performance is included, which may be available from academic researchers.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer assumed that the development of the constitutive relations for the selected alloy will include a robust model validation component. The future work as planned will contribute to overcoming the stated barriers to this technology.

Reviewer 2:
The reviewer commented that for the scope of effort, the proposed future research for the remainder of the project is outstanding because the Tier 1 supplier and the automotive OEM will be the principal performers. This will guarantee the transition of the technology and procedures to industry if test results are successful.

Reviewer 3:
The reviewer said that proposed includes work data generation for future design from the lab-scale experiments, and actual part manufacturing by the industry partner. The coordination is good but the actual plan for the part production depends on industry willingness to invest in tooling and experimentation.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer detailed that one DOE objective is to improve fuel efficiency of automobiles through using lightweight materials such as Al. These lightweight materials can be difficult to fabricate into components at a manufacturing scale because of certain mechanical properties, especially if the part manufacture is at room temperature. The reviewer remarked that this project develops a process to overcome these constraints and provides a modeling capability for iterative improvements in the process, if required.

Reviewer 2:
The reviewer commented that if successful, this work will contribute to the weight reduction target of lightweighting as laid out by the VTO (as mentioned on Slide 6; expected 30%-50% overall weight saving). The reviewer said that it remains to be seen (after the cost analyses) if the cost target will be met.

Reviewer 3:
The reviewer detailed that one DOE objective is mass reduction as it saves fuel and reduces greenhouse gas (GHG) emissions. Al can be used effectively to reduce the mass of a ferrous structure. The reviewer detailed that as more and more steel structural components are being replaced by alternate materials, it is necessary to develop information on the manufacturing and performance. This project is developing data on high-strength Al sheet material.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out this is a 3-year project that is funded at $1 million total. This is sufficient for the national laboratory to perform the initial experimentation and modeling as well as using results from the automobile manufacturer's testing to improve the models.

Reviewer 2:

The reviewer commented that the PIs are currently underspent, so it appears the funds will be sufficient. If the team keeps this spending rate, the funds will be more than enough, but that remains to be seen as the project is still relatively young.

Reviewer 3:

The reviewer said that the experiments are designed to study commercial grade Al. Quite significant information is available and efforts are needed to find and organize the knowledge.

Presentation Number: mat127
Presentation Title: USAMP Low-Cost Magnesium Sheet Component Development and Demonstration Project
Principal Investigator: Stephen Logan (FCA)

Presenter
Stephen Logan, FCA

Reviewer Sample Size
A total of four reviewers evaluated this project.

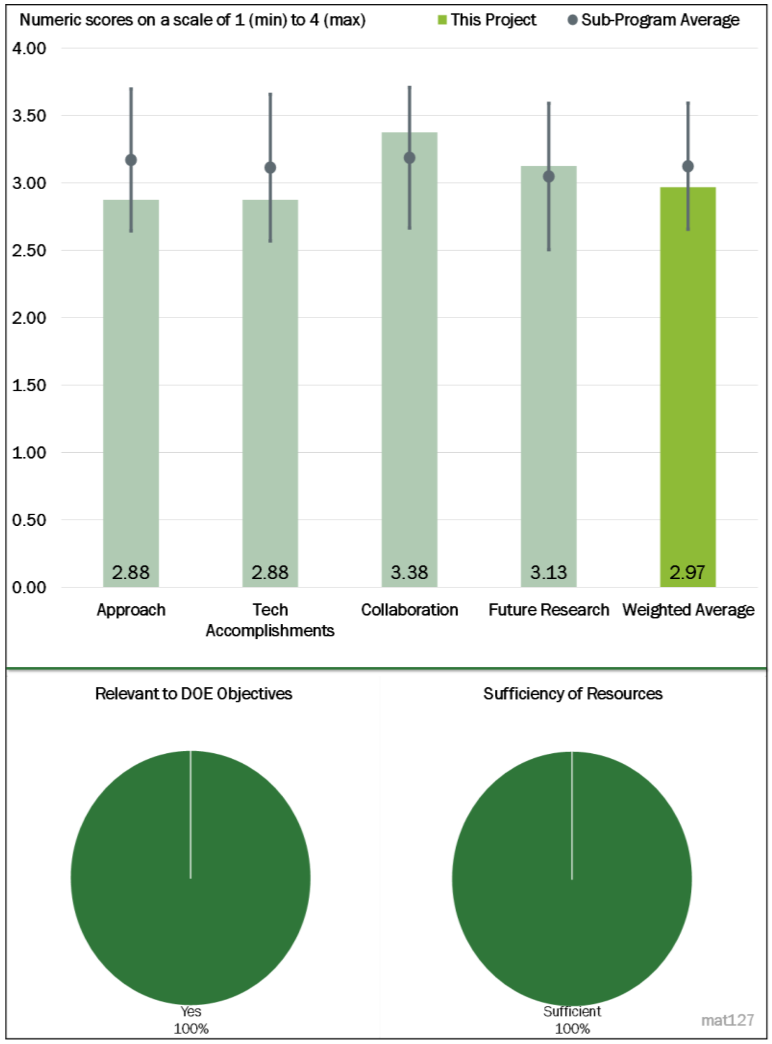

Figure 6-15 - Presentation Number: mat127 Presentation Title: USAMP Low-Cost Magnesium Sheet Component Development and Demonstration Project Principal Investigator: Stephen Logan (FCA)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer remarked that the approach is very sound for addressing manufacturing issues of a technology at a high TRL. This is a feasibility study to demonstrate the use of a lightweight material used in automobile manufacture at a substantial cost savings. The reviewer summarized that the project starts with a technical cost analysis and goes through a material selection process and experimental sheet production followed by development of coatings, formings, and joining methods for paint shop pretreating and ends with a technical cost and performance validation. The reviewer found that this is exactly the approach and process needed to achieve a cost reduction goal for use of Mg sheet in automobile manufacture.

Reviewer 2:
The reviewer said that efforts are being proposed to develop numerical modeling capability for the entire process cycle including alloy development, rolling and forming process, prototyping, coating, and paint shop processing. This is an exhaustive study of the process and the approach proposed is quite clear.

Reviewer 3:
The reviewer said that the approach is aggressive with regard to feasibility and cost targets, which is good for as large a team and project budget as this program has been afforded. This is a positive reflection on the project. The reviewer remarked that touting ICME as a critical component seems to have fallen largely by the wayside with the abrupt selection of ATMZ3100 as the material of choice following a literature search and a few calculations. It seems that the overarching premise of using computational tools to accelerate the materials development process was largely bypassed with what turned out to be a disappointing result. The reviewer remarked the capabilities of the team as a whole in providing the breakthrough material seem somewhat

underutilized when the process revealed a composition matrix that was rather ordinary (three alloys) and resulted in early testing of one (ATZM3100) that has yet-to-be-seen results. The reviewer said this was fully acknowledged as "jumping the gun," and the reviewer asked but what was the need was for it.

Reviewer 4:

The reviewer liked the holistic approach to this project, attempting to mimic production with all of the relevant steps. However, it did not seem like the task "Alloy and sheet processing development—New Mg alloy sheet composition(s) identified" is "complete." The question and answer session mentioned that the down-selected alloy had some issues and would need to be revisited. The reviewer said this seems like it is along the critical path, and may impact other tasks.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The viewer praised that the technical accomplishments over the past year and a half have been outstanding. The initial technical cost guidance for an automobile door panel resulted in identifying the rolled sheet metal cost as the largest cost driver, which validates the area of development needed for this component. A strip casting process was also identified as a constraint for new Mg alloys as part of this analysis. The team identified a Mg to be used in the rolling process that has improved performance at reduced rolling and forming temperatures. Coil-applied coatings were also identified from two separate suppliers and a warm-forming lubricant from two other suppliers. The reviewer detailed that the team is working with an industrial partner, and the PI was able to evaluate a potential paint shop pretreatment chemistry to work with the novel Mg alloy. CAE tools were used to evaluate the structural performance of a commercial automobile door inner and outer panels based on the commercially-available Mg sheet material. The reviewer found that, in total, this is quite a technical accomplishment given the timeframe that the work was done.

Reviewer 2:

The reviewer said that the limited results thus far seem to indicate the importance of working out the inter-company agreements before the project gets started. There was little detail on the university efforts, and it seemed that a shortcut backfired in alloy development. However, according to the reviewer the investigators seem to be moving along well in the areas of coatings and lubricants.

Reviewer 3:

The reviewer detailed how the project team established a consortium with various partners from a material supplier, academic institutions, DOE national laboratories, and industry partners. The team tested a new alloy; even though the performance of this new alloy is not up to expectations, the team is preparing for a new alloy development. The reviewer also pointed out that the cost modeling is completed with the identification of drivers, which need to be optimized to reduce the cost of the material.

Reviewer 4:

The reviewer said that the coatings approach on ZEK100 was interesting work and represented an appreciably large level of effort. The reviewer said it appeared that this is producing results that will have broader application. The bulk of the program at this point seems to be focused on commercially-available alloys (E-form Plus, and ZEK100). The reviewer inquired if adding process steps (coating) to these alloys going to get us anywhere near cost targets. The reviewer expressed having difficulty gleaning this information or the cost comparison with ATZM3100 from Slide 7.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer exclaimed that this project demonstrates an outstanding collaborative effort amongst 16 performers and 3 automobile manufacturers. The reviewer has not previously reviewed a project with this much collaboration.

Reviewer 2:

The reviewer said including LightMAT is a positive from the standpoint of collaborations, and there are no weak points here at all—a broad team with widespread capabilities and adequate involvement from industrial partners.

Reviewer 3:

The reviewer remarked that the team has been formed and is effectively communicating with monthly and quarterly meetings. The technical team from the United States Automotive Materials Partnership (USAMP) is discussing the progress weekly. The reviewer commented the team covers all the aspects of the process being studied.

Reviewer 4:

The reviewer remarked that the project has a strong group of stakeholders. It is not clear how all of the university efforts will be coordinated.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that although this project is in its early stages, the planning and milestones/decision points reflect an outstanding schedule for achieving the goals of this project and overcoming the barriers and challenges. The reviewer found that the schedule is maintained and milestones are met, no alternate development pathway will be needed.

Reviewer 2:

The reviewer pointed out that there remains a large component of the ICME-based work that will assist in sheet processing, so that is eagerly anticipated. The reviewer cautioned that not enough work has been done yet to indicate that ATZM3100 is the answer to the material cost issue (while maintaining performance measurables)—so the focus on future work that processes this material as the only avenue for material development runs the risk of a very strong program concluding that commercially available products are superior to what was developed by a very capable team, with little additional data on the Mg development process that might help future development efforts.

Reviewer 3:

The reviewer said that there seems to be a great deal of production challenges to overcome in Tasks 2 and 5, and these feed into Tasks 1, 3, 4, 6, and 7. The reviewer cautioned that modeling effort, particularly in atomistic crystal plasticity modeling and constitutive modeling, will be a challenge, and delays in production will significantly reduce the time these efforts are allotted.

Reviewer 4:

The reviewer remarked extensive work needs to be completed, and that alloy development will be the bottleneck for the project. The reviewer said that castability of the new alloy will be a challenge to overcome, and the supplier’s experience in the alloy development may help to reduce the risk.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer found that this program is squarely within the DOE objectives of energy efficiency through the lightweighting of vehicles. Programs such as this enable the deployment of lightweight technologies in the marketplace by increasing the cost-effectiveness.

Reviewer 2:
The reviewer remarked that this project supports an overall objective of DOE. One objective of DOE is to improve fuel efficiencies in automobiles through using lightweight materials such as Mg. The current high-cost of Mg sheet metal and the challenges in manufacturing automobile components with it prevent widespread use in the automotive industry. The reviewer detailed that this project addresses the barriers and challenges of using Mg sheet from an initial technical cost analysis through material selection, component manufacture, and final technical cost and performance validation.

Reviewer 3:
According to the reviewer, Mg is one of the materials which can be effectively utilized to reduce vehicle mass. The potential of this material is much higher than steels and Al. The reviewer pointed out, however, the cost of the material is a barrier and efforts to reduce the cost are always welcome.

Reviewer 4:
The reviewer acknowledged that the end goal is quite relevant. However, according to the reviewer there was a clear go/no-go missing from the approach. The cost model indicates that the biggest cost driver is the raw material. The investigators acknowledge that this is a critical assumption and out of the project scope. Given the geographic location of raw Mg sources, the reviewer asked the program managers, “Is now the right time?” The reviewer could see both sides, either continuing the project to get ahead of production problems for the day that the cost model or price point changes, or choosing to end the project so that the results will not get stale on the shelf. The reviewer wanted to be clear in expressing a belief that even with the challenges encountered, the team of investigators will conduct a successful project. Rather than doubt of the project team’s abilities, this reviewer clarified that the question should be taken as raising a point about a geopolitical situation that beyond the project team’s control.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer noted that the team is large, but the funding level is commensurate with the effort.

Reviewer 2:
The reviewer said that this is a large amount of funds for this project; however, there are a multitude of performers and collaborators that could justify the funding. If successful, the investments in materials development will be far exceeded by the cost savings by industry through using this material and processes.

Reviewer 3:
The reviewer pointed out that nearly $3 million is planned for the current FY. The reviewer said that many tasks associated with the manufacturing process, such as rolling mill lubricant, coating, and paint baking response of the sheet material, are being planned.

Reviewer 4:
The reviewer said that the overall resources are sufficient, the reviewer has some questions on resource allocation. Currently, the project seems heavy on production and fabrication, but thin on the computational side. The reviewer remarked that a great deal lies on the success of the next alloy developed.

Presentation Number: mat128
Presentation Title: Development of Low-Cost, High-Strength Automotive Aluminum Sheet
Principal Investigator: Russell Long (Arconic)

Presenter

Russell Long, Arconic

Reviewer Sample Size

A total of four reviewers evaluated this project.

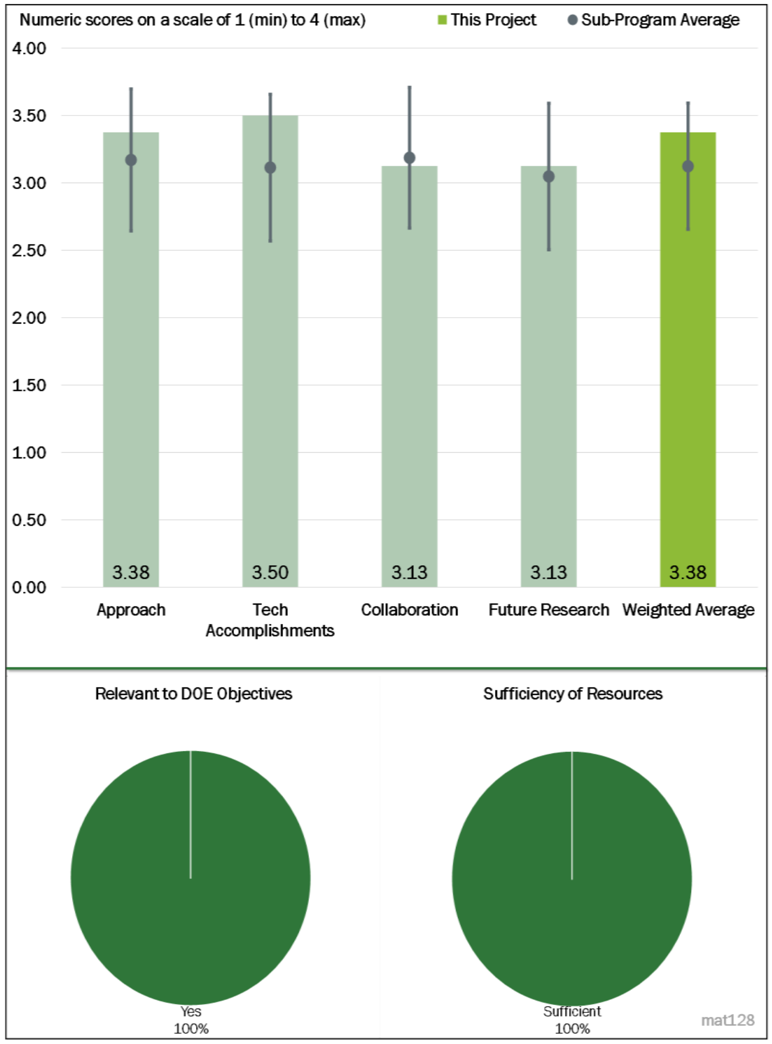

Figure 6-16 - Presentation Number: mat128 Presentation Title: Development of Low-Cost, High-Strength Automotive Aluminum Sheet Principal Investigator: Russell Long (Arconic)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer detailed that project objectives are to develop an Al alloy with specific mechanical properties within a specified processing temperature and specific cost for the finished product. The project is well-designed and feasible to meet these objectives with an approach that starts with alloy development and proceeds through tool design, process development, material property characterization, and ending in a cost study.

Reviewer 2:

The reviewer commented that the plan is good with partners form the whole spectrum of the supply team. The work includes the cost model as well as material optimization.

Reviewer 3:

The reviewer pointed out that the work is 80% complete, so most of the work has been carried out.

The reviewer detailed that cost modeling was done on the 2.4 mm thick material, instead of the 2.5 mm material. The reviewer asked what the implication is of the approximately 12% reduction in strength of the 2.4 mm material compared with the 2.5 mm material. The reason why the 2.4mm material was chosen for cost modeling over the 2.5mm materials is not clear to the reviewer. Testing was limited to only one configuration of component. The reviewer said this does not seem enough to establish confidence that the results will be similarly good for other component forms. The reviewer asked if there are any plans to test more component forms, especially as this process will be applied to more than the tested component form. The reviewer said that not enough detail is provided about the corrosion testing to be performed. The reviewer described that more detail about what went into the calculations of the cost per lb saved needs to be presented. For instance, what is "recycled scrap credit" and how was that applied to reach the $2/lb The reviewer inquired if the 2.5 mm material was considered, how much will the weight savings cost be.

Reviewer 4:
The reviewer remarked well-designed study. The results would have been improved by a deeper analysis of the failures in the bend and weld study.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer acknowledged that a lot of work was done and results obtained. These data will help achieve the overall goal of weight savings at a reasonable price

Reviewer 2:
The reviewer commented that the project appears to have met performance requirements.

Reviewer 3:
The reviewer pointed out that the project period is four and a half years. The reviewer summarized that a large amount of research and development has been conducted over this timeframe with some significant technical accomplishments in material forming/tooling, forming simulation, new Al alloy development, component fabrication and testing, material selection, prototype testing, corrosion evaluation, joining trials, and a cost analysis resulting in significant weight savings and a cost per pound saved close to the target of $2/lb. According to the slide on Remaining Challenges and Barriers, there are still some improvements and additional information needed to meet all of the objectives for this project. The reviewer commented this will be difficult to accomplish with the remaining time of 6 months left on the project.

Reviewer 4:
The reviewer remarked that iterations on the alloy composition have been conducted to obtain a compromise on formability and strength. The alloy's highest strength does not exhibit targeted ductility. The reviewer noted that the qualification testing procedure has been developed and will be used to compare the test alloys. Also, actual parts have been fabricated using a test die. The reviewer found that all aspects of a development project have been properly planned and coordinated. Also, the efforts on tailor welded blanks needs to continued, which will further reduce the material use.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer said that collaboration involves a national laboratory, a materials producer, a Tier 1 supplier and an automobile OEM. The level of testing can be easily performed by the national laboratory or the materials supplier so involvement by academia would not be required for the technology at this readiness level. The reviewer found that the presenter also showed good coordination between the materials producer and Tier 1 supplier when processing equipment was moved to another production line.

Reviewer 2:
The project team is vertically integrated with an OEM, Tier 1 supplier, material provider, and a national laboratory. The design requirements are provided by an OEM, and a Tier 1 supplier is conducting experiments. The reviewer pointed out that variations of the alloy are being produced by the material supplier. The results presented indicate a compromise on the strength and formability. The reviewer remarked well-planned and executed project with proper coordination.

Reviewer 3:

The reviewer said that there seems to have been good collaboration amongst the partners. It would have been nice to know what percentage of the work each collaborator contributed to.

Reviewer 4:

The reviewer observed that partners seem to play a passive role. For example, Honda only provided formability and corrosion targets when it could have been involved in the analysis. The reviewer said that the impact of other partners is unclear.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that this project is concluding in the next 7 months, so there is not the time or the funding to address the proposed future work. Improvements sought through further forming trials and joining quality will likely not be achieved and the additional cost reduction options cannot be effectively pursued because of lack of data from the forming trials.

Reviewer 2:

The reviewer remarked good future work and approach. The reviewer noted that the corrosion testing approach is not discussed.

Reviewer 3:

The reviewer said that the project has incorporated appropriate decision points and is considering technology and implementation barriers. The reviewer noted that risk mitigation is not well described.

Reviewer 4:

The reviewer said this is the last year for the project.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that high-strength Al sheet is necessary to meet the weight reduction targets of DOE as more and more HSS structural components need to be replaced. This project addresses this concern by encouraging the development of high-strength alloys.

Reviewer 2:

The reviewer said yes, and elaborated that the development of high-strength, lightweight, low-cost alloys that are formable is an ambitious task and highly relevant to DOE. The results of this work could have a significant impact on the automotive industry.

Reviewer 3:

The reviewer agreed that this project supports an overall objective of DOE. One objective of DOE is to improve fuel efficiencies in automobiles through using lightweight materials such as Al. The current challenges in manufacturing automobile components with Al prevent full use in the automotive industry. The reviewer said that this project attempts to solve some of the issues with material properties, parts processing, and component joining coupled with a cost study.

Reviewer 4:

The reviewer commented that the project contributes to weight reduction at reasonable vehicle cost targets for VTO.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked resources are sufficient and the project was able to achieve its milestones.

Reviewer 2:

The reviewer noted that project length is 4-1/2 years at a total cost of about $4.8 million, which is about $1 million per year. This should be sufficient to achieve the stated milestones in a timely fashion. The reviewer said that for reasons not totally explained by the presenter, there is still some significant work to be done with very little time to accomplish the final results.

Reviewer 3:

The reviewer said that there seem to be enough resources to complete this work, going by the word of the PI. Without opening the books and reviewing expenditure by task projection and actuals, there is really no way of confirming that the team has sufficient funds to complete this work.

Reviewer 4:

The reviewer said last year of the project; no funding request.

Presentation Number: mat129
Presentation Title: Optimizing Heat-Treatment Parameters for 3rd Generation Advanced High-Strength Steel Using an Integrated Experimental Computational Framework
Principal Investigator: Xiaohua Hu (Pacific Northwest National Laboratory)

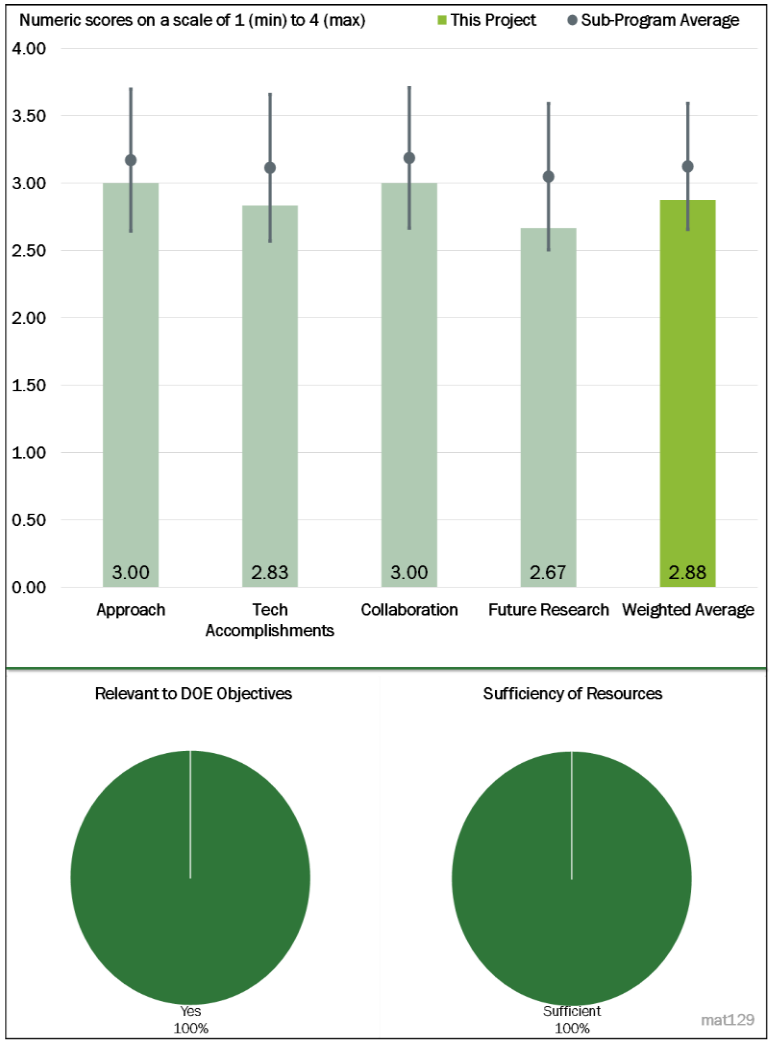

Figure 6-17 - Presentation Number: mat129 Presentation Title: Optimizing Heat-Treatment Parameters for 3rd Generation Advanced High-Strength Steel Using an Integrated Experimental Computational Framework Principal Investigator: Xiaohua Hu (Pacific Northwest National Laboratory)

Presenter

Xiaohua Hu, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the flow diagram for the approach illustrates a well-designed and systematic process for obtaining the needed information to meet the project objectives and to address the barriers and challenges with the use of third-generation advanced high-strength steels (3GAHSS). The approach is feasible in concept but has not completely answered all the questions surrounding the use of these materials.

Reviewer 2:

This reviewer found it challenging to follow the approach of the work, although the objective of the work seems straightforward and clear. The reviewer detailed the project's approach, describing that the relevance and objectives are development of an integrated in situ and ex situ experimental and numerical modeling framework for Med-Mn 3GAHSS to: determine accurate thermodynamic parameters; optimize inter-critical annealing parameters, microstructure, and superior combined mechanical properties of ductility and strength suitable for vehicle lightweighting; meet DOE VTO Multi-Year Program Plan targets and goals; and help steel makers and users expedite the development to deployment cycle.

The reviewer found that the way the work was laid out was not optimal. It was difficult to follow how the tests, as well as the modeling and simulation work carried out, fit together to build the numerical framework. The reviewer said that this needs to be clarified better. The reviewer suggested it may be prudent to start with a list of parameters that must be used to develop the framework for each subgoal, why they are important (define the physical meaning and significance of each parameter; e.g., PLP, AI parameters, what are they, what are the physical meanings and why are they important to this framework); and how they would be obtained. The reviewer cited, for instance, will experimental work be required to provide input data for simulations used to develop the framework.

The reviewer described that one of the difficulties of this work seems to be that the authors may be trying to take on too many things at the same time. However, the exercise described above might help determine this, and whether one framework model or more are required to reach each of the subgoals detailed above. The reviewer is not satisfied with the approach with regard to model validation. Model validation must be carried out with data not originally used to develop models or submodels for this work. The reviewer found that the presentation did not describe in any degree of detail how model/framework validation will be achieved.

Reviewer 3:

The reviewer said that the project is aimed to develop numerical models to predict the final response of the alloys for heat treatment. Heat treatment is a complex process with diffusion, precipitation, and growth phenomenon occurring simultaneously, impacting the final structure and hence properties. Most of the times the development is through a trial and error process making it expensive and time consuming. This project is planning to conduct experiments and measure the kinetics of these reactions to develop modeling of the process. This will help designers see parameters.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed that there has been outstanding progress in the technical accomplishments for most of the project objectives in order to meet the performance measures and milestones, e.g., in situ inter-critical annealing heat treatment experiments, ex situ heat treatment materials characterization, simulations for phase transformation during inter-critical annealing, phase field microstructure modeling and microstructure, and mechanism-based phenomenological and crystal plasticity finite element modeling. The reviewer said that there is still more materials and data to be generated and not much time to obtain accurate models.

Reviewer 2:

The reviewer commented that a new in situ characterization technique of steels during heat treatment had been developed. This is used to measure the retained austenite and its stability. The reviewer also pointed out that the presence and amount of C and Mn on the precipitated phases can be estimated. This will help to model the diffusion and precipitation process. The reviewer noted that this effort will be supplemented by external characterization. Per the reviewer, the project successfully completed modeling efforts on the Luder Band formation during the transformation.

Reviewer 3:

The reviewer described how the “Fair” rating is based on the fact that the work was difficult to follow, and hence it is also difficult to gauge the impact of the eight accomplishments listed on the overall success of the work. The reviewer said that clearly defining what needs to be done will go a long was in helping to properly assess the impact of the current accomplishments on meeting the overall goals of the work.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer detailed that listed collaborators include Colorado School of Mines, Argonne National Laboratory, and ORNL. The task of each team member is fairly well spelled out. The reviewer said each team member should help one another in better defining the scope of work, and making an assessment as to whether too many things are being crammed into the framework.

Reviewer 2:

The reviewer remarked three U.S. DOE national laboratories are in collaboration with the steel research center at the Colorado School of Mines in this project. The steels are being supplied by industries involved in the steel research center at Colorado School of Mines.

Reviewer 3:

The reviewer observed that collaboration is limited to three DOE national laboratories and the Colorado School of Mines without involvement from Tier 1 suppliers or OEMs or multiple academic institutions. This was a reviewer comment at last year's AMR and is addressed on Slide 17; however, there is still no description of how the results of this $1.3 million project will transfer to industry, other than through the academic institution. The reviewer noted that although the project is addressing issues at an early-stage of research, the Colorado School of Mines should still be able to identify technology transfer partners for this project, which will end in another year.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that confirmation of the models by measurements needs to be completed.

Reviewer 2:

The reviewer said that although the project was effectively planned, the future work described is a significant amount to be accomplished with only 15 months left on a 4-year project that is stated to be 50% complete in June 2018. The two remaining milestones were presented as "on track;" however, there is a large amount of studies and development left to perform in a very limited time.

Reviewer 3:

The reviewer remarked that this is also given a "Fair" rating based on the fact that the work is difficult to follow, and hence a difficulty exists in figuring out whether the future work as defined will be enough to reach the stated goals. The work being better defined will go a long way in helping to make this assessment more accurately.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer remarked this project supports an overall objective of DOE to improve fuel efficiencies in automobiles through using lightweight materials such as 3GAHSS. The lack of fundamental understanding and quantitative measurements of alloying content, heat treatment parameters, microstructure, and mechanical properties coupled with the challenges in manufacturing automobile components with it prevent widespread use in the automotive industry. This project addresses the barriers and challenges associated with traditional heat treatment processes of 3GAHSS.

Reviewer 2:

The reviewer pointed out that the development of good AHSS would assist in reducing the overall glider weight of vehicles, which is a stated goal of VTO. If this framework delivers as promised (based on the four sub-goals), AHSS development and manufacturing would be easier, faster and probably cheaper. These are all good things for vehicular glider weight reductions.

Reviewer 3:

The reviewer noted how HSS are one of the ways to reduce the weight of the vehicles without compromising the safety. The HSS always require heat treatments to improve the properties and a trial and error process of optimizing this process is expensive. The reviewer remarked understanding the physics and developing models will pave way for faster development process and confidence in the materials.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the estimated cost of 700,000 will be sufficient to complete the planned tasks.

Reviewer 2:

The reviewer pointed out this is a 4-year project funded at $1.3 million (DOE and in-kind). This is about $300,000 per year, which is sufficient for the level of research being conducted by various laboratories and should achieve the stated milestones within the project period.

Reviewer 3:

The reviewer said that this is difficult to determine, and the review had to choose an option.

Presentation Number: mat130
Presentation Title: Enhanced Sheared Edge Stretchability of Advanced High-Strength/Ultra-High Strength Steels
Principal Investigator: Kyoo Sil Choi (Pacific Northwest National Laboratory)

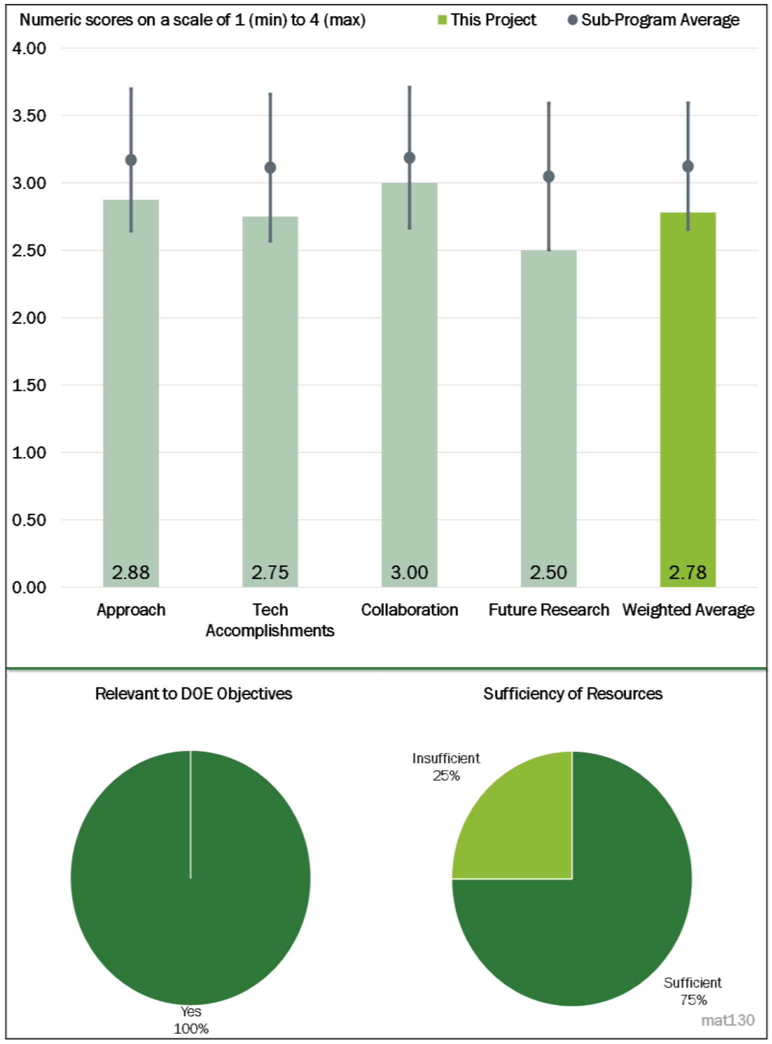

Figure 6-18 - Presentation Number: mat130 Presentation Title: Enhanced Sheared Edge Stretchability of Advanced High-Strength/Ultra-High Strength Steels Principal Investigator: Kyoo Sil Choi (Pacific Northwest National Laboratory)

Presenter

Kyoo Sil Choi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer described that using advanced materials such as AHSS and ultra-high strength steels (UHSS) in automobile manufacture is hindered because of damage occurring during fabrication of component parts, in this case trimming the edges of the component part. Stretchability at the material’s edge is an important factor. The reviewer found that the approach used in this project starts with a literature review and continues through characterization of material properties, simulations and experiments, and ends with optimizing cutting parameter using predictive analysis to enhance the stretchability at the materials edge. The reviewer remarked this is a sound approach to solving any material defects problem.

Reviewer 2:

The reviewer remarked that the approach was largely successful in achieving program goals, so there is little to fault from that standpoint. The reviewer noted that successful validation of a modeling approach is always a bit subjective, however. The dependence upon edge shapes and macro-scale deformation models lacked a bit of detail—more microstructural characterization of incremental deformation modes as well as detailed fracture surfaces would have been a very valuable information set to add to the program curriculum.

Reviewer 3:

The reviewer said that the team has used tensile testing and some analysis of microstructure to improve on enhanced sheared edge stretchability. The reviewer cited as an example how the team was able to determine that strength differences in microstructural components contributes to poorer stretchability and reducing this by heat treatment can improve on this. However, according to the reviewer these simple tensile tests are too simple and do not take into account the complexity of 3-D geometry such as the hole punch shown. The reviewer asked what the effects are of rolling direction, and of rate of shear, etc. The reviewer said that all of these effects are not being considered.

Reviewer 4:
The reviewer commented the quantitative approach does not identify the root cause formability difference between material supplied by Supplier A and Supplier B. The volume fraction/presence of voids was not considered in the conclusion. It seemed to this reviewer that a hypothesis of relative hardness between martensitic and ferritic phase was proven rather than a scientific assessment of the contribution associated with the hardness differential between the dual phases of each material. The notion and comparison between to performance of a dull punch versus sharp punch signifies the elementary approach taken to a complex problem.

The reviewer commented that the solution to temper the martensite to reduce the hardness differential between the phases is a means to prove the hypothesis. Rather, the comparison of a tempered material proved that lower strength material has better edge stretch formability than a higher strength material.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer found that the results for materials characterization for two steels and the comparison of edge stretchability met the performance objective of obtaining a fundamental understanding of the role of microstructure on sheared edge stretchability. The successful results of using computational methods and comparisons with experimental data met the performance objective of building a predictive capability to quantify relationships between microstructure and characteristics of the material at its edge. Computational results were also successful in predicting trimming induced damage.

Reviewer 2:
The reviewer commented that there is certainly value in the accuracy of the modeling tool in predicting trim-induced damage, not only from the standpoint of optimizing the process but also for understanding the time-dependent degradation of the process as trim tools wear.

Reviewer 3:
The reviewer observed that the project team was able to conclude that heat-treating DP2 steel improved on stretchability. However, the reviewer asked what impact this heat treatment has on other properties of the material, and if this is a realistic solution. The reviewer inquired what the best solutions are to improving on the stretchability of the high-strength and ultra-high-strength alloys.

Reviewer 4:
The reviewer remarked that work was completed; however, the intrinsic value of the technical accomplishment is minimal if any.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer observed the program has an ideal mix of talent/experience/capabilities, with an OEM and two producers supporting the scientific efforts. The reviewer would have liked to see the breakdown for cost-share partners as a matter of interest (the reviewer asked how much the steel producers contributed and was it materials only or cash/in-kind as well).

Reviewer 2:
The reviewer said that this project demonstrated outstanding collaboration involving a national laboratory, academia, two steel manufacturers, and an automobile manufacturer. The reviewer said that coordination amongst these partners resulted in achieving the project objectives within the period of performance.

Reviewer 3:
The reviewer acknowledged that collaboration took place. The reviewer would expect better guidance by the industrial partner to yield a meaningful result.

Reviewer 4:
The reviewer said that although reasonable work has been done in the modelling, given that this is the final year of the project and only thin tensile samples are being evaluated, and only at a limited scale, the collaboration with partners appears minimal.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the program is 95% complete and seems to be on target.

Reviewer 2:
The reviewer remarked there is no proposed future research; the project has ended.

Reviewer 3:
The reviewer said the project has ended this month.

Reviewer 4:
The reviewer commented work is done, nothing gained.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer pointed out using HSS and UHSS will reduce mass and increase efficiency. Improvements that enable the use of these steels support DOE objectives

Reviewer 2:
This project supports an overall objective of DOE to improve fuel efficiencies in automobiles through using lightweight materials such as AHSS. The challenges such as edge stretchability during forming operations in manufacturing automobile components with it prevent widespread use in the automotive industry. This project addresses the barriers and challenges of using AHSS from an initial literature review through material selection, component testing, and predictive modeling.

Reviewer 3:
The reviewer commented the topic of edge stretch formability is relevant. The value of the result is minimal.

Reviewer 4:
The reviewer remarked it requires some level of imagination to understand specifically what the cost targets are and whether they were achieved. What is the manufacturing estimate of cost savings—the reviewer asked if it is based on material feasibility, or reduced scrap rate. The reviewer said it may be a complex combination of many factors, but this was not elucidated.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said with 100% completion essentially at hand, the resources were apparently adequate.

Reviewer 2:

The reviewer said that the project period of performance is 3-1/2 years and the over-funding level is $1.35 million, which is about $385,000 per year. This is sufficient funding for the level of research being conducted and the number of partners involved.

Reviewer 3:

The reviewer found that resources were sufficient, and increased involvement by industry in the planning phase would have provided a more meaningful result.

Reviewer 4:

The reviewer commented that based on what was shown and that the project is now completed, this reviewer did not believe enough was achieved with the milestones to effectively solve the problems with edge stretchability.

Presentation Number: mat131
Presentation Title: Corrosion Control in Carbon Fiber Reinforced Polymer Composite—Aluminum Closure Panel Hem Joints
Principal Investigator: Brian Okerberg (PPG Industries)

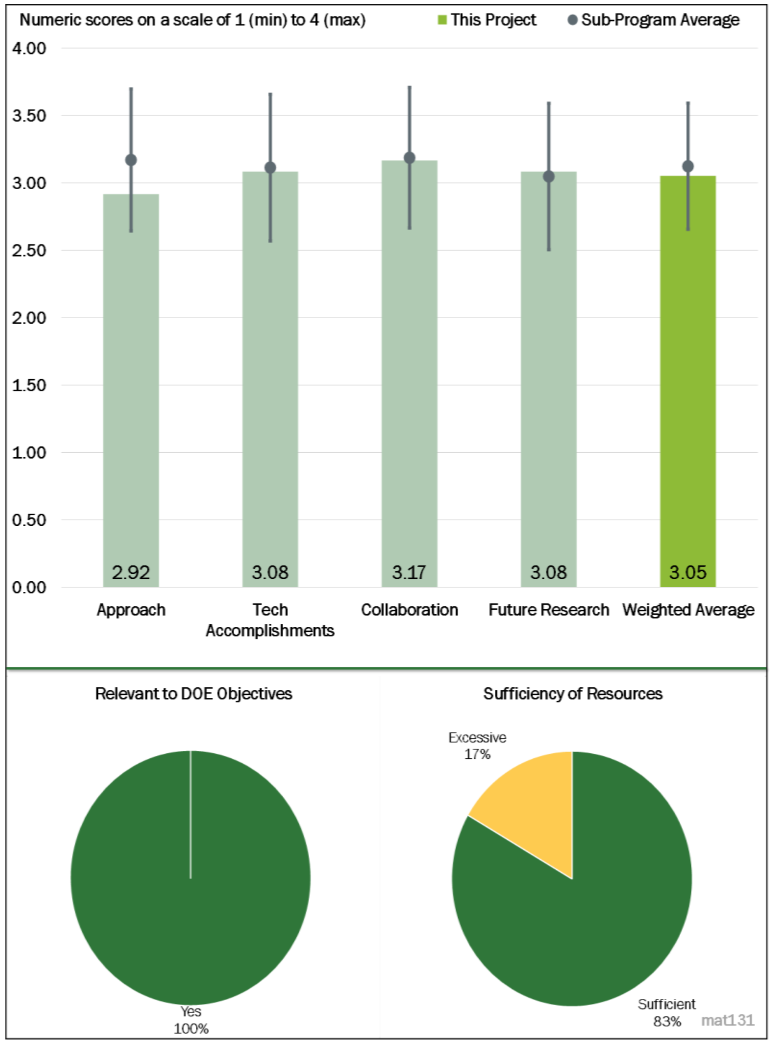

Figure 6-19 - Presentation Number: mat131 Presentation Title: Corrosion Control in Carbon Fiber Reinforced Polymer Composite—Aluminum Closure Panel Hem Joints Principal Investigator: Brian Okerberg (PPG Industries)

Presenter

Brian Okerberg, PPG Industries

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that including both types of CFRP (twill and continuous fiber) will cover the future production options. The development of an adhesive and conductive primer will be required to make this combination viable.

Reviewer 2:

The reviewer remarked that the project precisely addresses the technical objectives. The design is definitely near-commercial readiness level although it is not highly novel from research and development standpoint. The materials formulation was randomly chosen but more keeping commercial readiness in mind rather than developing a research hypothesis for expanding or contributing to science.

Reviewer 3:

The reviewer said that this addresses a broad class of structures that are not practical today because they are incompatible with existing industry curing temperatures.

Reviewer 4:

In this reviewer's opinion, this project has an Edisonian approach. The reviewer did not see any solid chemical/electrochemical background and their interrelation for this work. The reviewer said that some degree of basic science and explanations of the results are always a must in any technical project. Slide 10 has an indication of all the parameters that are considered for the development work, which is a positive step, but no results (reasons, base, or fundaments) are explained and even, at a low- or small-level, explanations and reasons of the results are needed for the "prediction" of the effects. The reviewer remarked that an electrochemical model will be even better for future applications.

Reviewer 5:

The reviewer observed a good approach, but recommended a numerical versus an observation approach.

Reviewer 6:

The reviewer commented the presentation material failed to provide a comprehensive plan on how the technical barriers would be addressed. A reference to predictive accelerated corrosion tests was included in the Technical Challenges; however, the overall plan did not reference how to address predictive modeling. The reviewer noted that Budget Period 1 referred to understanding the nature and the extent of a problem from a fundamental point of view, but no references to fundamentals was covered in the presentation material. The reviewer recommended the team reassess the project plan and milestones to reflect how the activities provide a fundamental understanding into the project objectives. The reviewer noted that joining Al to CFRP at 150°C for 10 minutes for hem flange adhesives for closures require the development of suitable test techniques relevant to size and geometry associated with closure system.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer reported that there is good progress being made on initial corrosion testing and development of primer and adhesive that meets the 150°C at 10 minute cure cycle. The coefficient of thermal expansion (CTE) mismatch will be difficult to accommodate. The reviewer observed that the project team’s CTE samples, which show the bowing on Slide 15, should be longer (close to the length of a door or hood edge if that is the target condition).

Reviewer 2:

The reviewer observed a good level of activity and accomplishment.

Reviewer 3:

For this reviewer, there were no questions that progress has been made. Now, the question is if this progress has been made systematically, and if the next step is then taken based on an analysis of the prior results and its conclusions. The reviewer expressed interest in seeing a table with indications of a path as a function of already-achieved results.

Reviewer 4:

The reviewer noted that this is the first year of the project so the majority of work has not been initiated.

Reviewer 5:

The reviewer recommended that the project team should conduct a temperature sensitivity and present this at the next AMR to elucidate if the chosen low-cure adhesive is at the optimal performance at the chosen temperature.

Reviewer 6:

The reviewer referenced prior comments.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that there seems to be active participation between Ford, The Ohio State University, and PPG.

Reviewer 2:

The reviewer remarked that it seems like very good collaboration across teams, and the OEM is actively engaged.

Reviewer 3:

The reviewer found that from the provided information, it seemed that a good collaboration and interaction exist between these three organizations. The reviewer noted how produced samples are sent to different organizations for their evaluations. The reviewer noted that all of the involved organizations are well-known and recognized.

Reviewer 4:

The reviewer recommended that the project team should consider how activities from one partner support the rest of the project. For example, the authors made references to electrochemistry technical accomplishments, but the reviewer did not see or recall from the verbal portion of the presentation how such findings support the overall project or what targets are necessary to be achieved from an electrochemistry point of view to deal with barriers the project is supposed to address.

Reviewer 5:

The reviewer recommended that collaboration with the OEM needs be increased to ensure relevance.

Reviewer 6:

Good blend of industry and OEMs.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted a well laid-out plan that addresses several aspects of the technology that require development in order to deploy production.

Reviewer 2:

The reviewer said that this project has listed continued development of the adhesive for high CTE mismatch and conductive primers for use of low-temperature e-coat. The project team will be evaluating alternative joint designs including the baseline hem design. The reviewer believed the CTE samples should have lengths similar to the joint length in a door or hood application.

Reviewer 3:

The reviewer remarked that the proposed future research appeared to be somewhat decoupled, and there were no references at all to predictive modeling.

Reviewer 4:

The reviewer observed future work depicted on Slide 19, which indicated numerous future experimental steps, mainly about producing samples and subsequently subjecting them to evaluative testing. The conclusions and decision made, based on theoretical needs, are missing and needed to direct the next experiments. Furthermore, according to the reviewer these results could help feed a model or/and further develop a model, even if this model is basic at this moment, but will build the base for a better model later.

Reviewer 5:

The reviewer recommended that it would be good to include even continuous CF, which is more prominently used in automotive owing to their high mechanical performance.

Reviewer 6:

The reviewer recommended that future research be quantitative versus qualitative in nature.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer said the project is well-aligned to DOE objectives.

Reviewer 2:
The reviewer pointed out that joining of material with different CTE mismatch is a very fundamental problem which needs to be addressed.

Reviewer 3:
The reviewer responded that the researchers are using automotive future materials in joint configurations similar to those expected to be used. The corrosion and CTE impact on those samples are being studied per DOE goals.

Reviewer 4:
The reviewer saw that this project is very relevant. The need to quantify the interactions between materials is imperative to realize multilateral lightweighting objectives.

Reviewer 5:
The reviewer remarked the project addresses new material combinations that today are not practical but would provide significant weight savings.

Reviewer 6:
The reviewer expressed a preference for answering this question with “Partially,” and it is not possible under the two only available answers. The reviewer really thinks that this research should be done completely and totally by the car industry together with the resin/coating (chemical) company. These entities will be the beneficiaries of this technological approach indirectly (and from here come this reviewer’s “partially” grade). The reviewer said that DOE should be more involved in areas where the investment is “too risky or too costly” for the private world and (in this reviewer’s very personal opinion), and this project does not meet this standard.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the team appears to be on track with their milestones.

Reviewer 2:
The reviewer said that it appears sufficient resources are deployed.

Reviewer 3:
The reviewer remarked that the team has requisite resources.

Reviewer 4:
The reviewer said that resources are appropriate.

Reviewer 5:
The reviewer thought yes, the team can (and they surely) meet all the project milestones in a timely fashion. The resources, manpower, and institutions are there.

Reviewer 6:
The reviewer said more engagement by an industry partner is needed.

Presentation Number: mat132
Presentation Title: High-Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding
Principal Investigator: Glenn Daehn (Ohio State University)

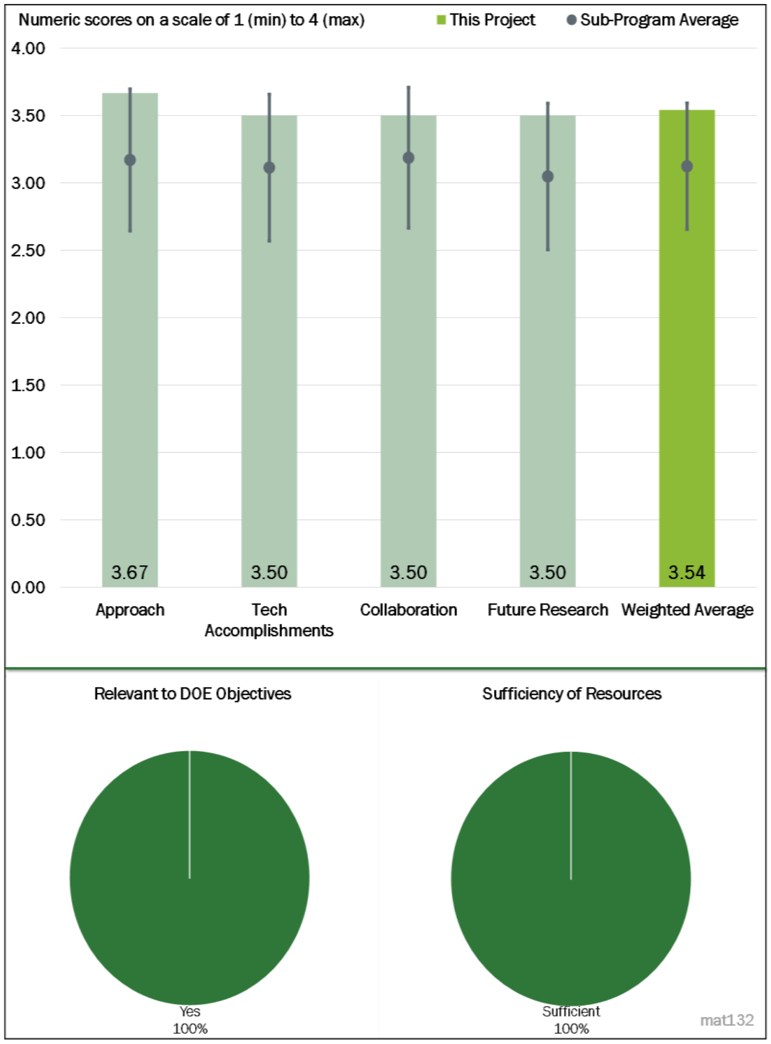

Figure 6-20 - Presentation Number: mat132 Presentation Title: High-Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding Principal Investigator: Glenn Daehn (Ohio State University)

Presenter

Glenn Daehn, Ohio State University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach is designed to accelerate and focus the development of a method for joining dissimilar materials in an expedient manner. The approach is to start with a known technology, vaporizing foil actuator welding, and optimize it for joining Al to HSS. The reviewer pointed out that both are considered lightweight materials by the automotive industry. The approach is sound from the aspect of starting with coupon selection and moving through coupon testing, prototype component fabrication, production and testing of the prototype component, and ending with the design and construction of a production-scale robotic welding system. The reviewer noted that throughout the project, part of the approach is to do numerical model development and model validation using test data to improve the process.

Reviewer 2:

The reviewer said that the approach presented appeared very logical.

Reviewer 3:

The technical objectives are well laid out with an apt feasibility plan. There is not any fundamental issue being addressed, but the technology being developed takes into consideration the commercial-readiness for which state, it is aptly proposed and planned.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that good progress has been made, and the team is on course to meet proposed objectives.

Reviewer 2:

The reviewer said that although the project is only 30% complete, there has been excellent progress and results for the welding of five different pairs of Al-steel coupons, good results for corrosion testing, and good characterization of intermetallic compounds formed during the welding process. Development of a prototype welder has begun and a computational model has been validated on the interface morphology of an Al-steel weld. The reviewer noted that the team selected a prototype component, the engine cradle for a 2016 Chevrolet Cruze, for the full-scale testing. The reviewer found that all of these demonstrate outstanding progress to date for a project that is only one-third through the performance period.

Reviewer 3:

The reviewer expressed a bit of concern with the delay of the prototype design, supporting CAE results, and the impact it could have on the timely finish of the project. The reviewer highly encouraged the team to include activities at coupon or component level for the sensitivities in bond gap, and the necessary control of bond gap to achieve optimum joint strength performance.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed great collaboration within the team.

Reviewer 2:

The reviewer found that the collaboration for this project is excellent because it involves a national laboratory, three materials suppliers, a testing company, an equipment builder, and a university. The reviewer recommended it would be good to have an automobile manufacturer involved; however, there is an interface available for technology transfer through the equipment builder.

Reviewer 3:

The reviewer remarked that the project appeared to have excellent collaboration among project partners.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that the proposed future work is for the design and build of the prototype component and a production-scale welding system, which is to be accomplished during the remainder of the performance period. The milestones presented support a successful development of the end product. The reviewer noted that this project is mostly manufacturing development of technologies at a higher TRL where risk has been minimized previously during the advanced development phase.

Reviewer 2:

The reviewer recommended that it would be good to also have a real component testing planned rather than sticking to sub-component testing.

Reviewer 3:
The reviewer referenced prior comments related to understanding the sensitivities to necessary gap control and tolerances.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer remarked yes, the project indeed supports DOE objectives.

Reviewer 2:
The reviewer said this project supports an overall objective of DOE to improve fuel efficiencies in automobiles through using lightweight materials such as AHSS and Al. The current high cost of AHSS and the challenges in manufacturing automobile components when joining AHSS to Al prevent widespread use of these materials in the automotive industry. The reviewer detailed that this project addresses the barriers and challenges of joining these materials on a pre-production scale from an initial material selection, coupon testing, component manufacture and test, and final design and build of an automated welding system. The reviewer remarked that the testing is supported throughout with development and validation of a numerical model.

Reviewer 3:
The reviewer agreed that evaluating alternative solid state joining for lightweight material applications is certainly tied to program office objectives.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented the team does have sufficient resources to accomplish the proposed objectives.

Reviewer 2:
The reviewer detailed that the performance period for this project is 4 years and has total funding of $2.7 million, which is almost $700,000 per year. Because the project involves mostly prototype manufacturing and testing, the resources for the seven partners are sufficient to produce the desired results.

Reviewer 3:
The reviewer remarked sufficient resources appear to be deployed.

Presentation Number: mat133
Presentation Title: Corrosion Protection and Dissimilar Material Joining for Next-Generation Lightweight Vehicles
Principal Investigator: D.J. Spinella (Arconic)

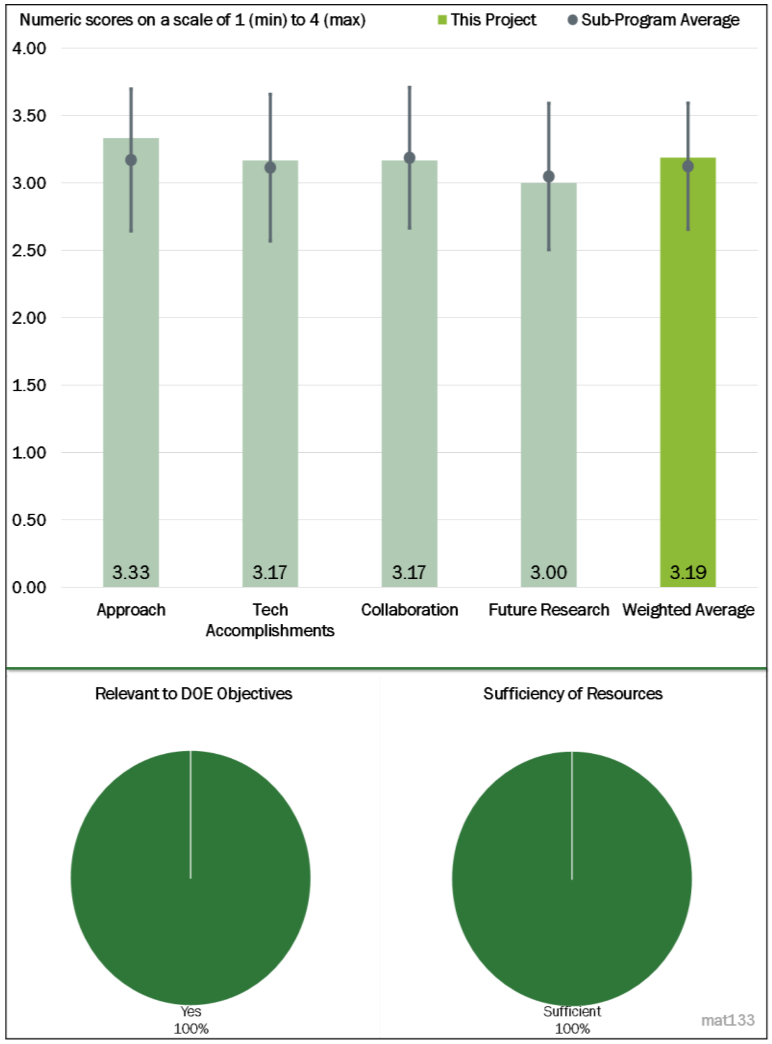

Figure 6-21 - Presentation Number: mat133 Presentation Title: Corrosion Protection and Dissimilar Material Joining for Next-Generation Lightweight Vehicles Principal Investigator: D.J. Spinella (Arconic)

Presenter

DJ Spinella, Arconic

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the work described is well laid out, and clearly focuses on first providing definition of a specific class of technologies, establishing processing requirements, and finally testing the resulting components. Testing across a number of the partners is a plus. The reviewer said that a better interpretation of the process physics and metallurgy would be beneficial.

Reviewer 2:

The reviewer commented good approach, a high-volume application is the vision.

Reviewer 3:

The reviewer said that the approach is very comprehensive, which covers the related testing, from process developments for different material combinations, mechanical strength analysis, corrosion testing, and comparisons with base joining techniques, to demonstration in automotive manufacturer. The reviewer observed that it might be challenging to use a resistance spot riveting method to join long-fiber CFCs because the long fibers are difficult to cut through by rivet or machining.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer commented that the team has accomplished the proposed tasks completely in the first budget period, and partially for the second budget period. The reviewer found that overall, the project is managed under a well-designed timeline and follows well for the go/no-go strategy.

Reviewer 2:

The reviewer remarked good progress to date.

Reviewer 3:

The reviewer said that the project appears to be slightly behind schedule. The reviewer saw no reason, however, that this project cannot catch up and complete within the allotted time.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked the collaboration between Arconic as both a fastener supplier as well as a process technology developer, The Ohio State University for high-level corrosion expertise, and Honda as an OEM designer and implementer appears to be ideal. The reviewer found that this should provide continuity from understanding and mitigating any corrosion issues to fully equipped systems and rivet provider to a final product implementer.

Reviewer 2:

The reviewer remarked that the team is well-formed, where each partner contributes their unique expertise to the project. The assignments are clear between the partners/collaborators. The reviewer said that for the first year of the project, it seems most contributions are from Arconic, Inc. and The Ohio State University, which is determined by the nature of proposed work. The reviewer remarked more collaborations could be seen along with the project development.

Reviewer 3:

The reviewer recommended that increased collaboration is needed. The university and OEM seem to be working independently versus collaboratively.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found, to be honest, the risk factors for future research appear to be relatively low. The processes have been demonstrated and the initial corrosion results appear to be attractive. The reviewer said it appears that the remaining work will largely provide data allowing future implementation of the technology.

Reviewer 2:

The reviewer said that the future research is comprehensive and aligns well with the proposed milestones. The proposed work should have addressed the challenges and barriers. The reviewer pointed out that the link between remaining challenges/barriers (Slide 18) and proposed future research (Slide 19) somehow is missing in the author's slides.

Reviewer 3:

The reviewer remarked future research regarding qualitative corrosion test results need to be included. The reviewer said "as good as" is an opinion, not a qualitative research finding.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer said that the project is one of many steps necessary to enable true multi-material vehicles (particularly incorporating CFRP's) into high-volume production.

Reviewer 2:

The reviewer said yes and elaborated that the corrosion in dissimilar material joints is a critical issue and can hinter their applications in many industries, especially in transportation sector. The reviewer pointed out it is also well-known that the dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollutions. Thus, the reviewer found that this project supports the overall DOE objectives.

Reviewer 3:

The reviewer noted that joining technologies are very relevant to multilateral vehicle construction to achieve mass reduction objectives.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 2:

The reviewer remarked resources seem sufficient.

Reviewer 3:

The reviewer said that the team appears well-equipped to complete the stated objectives within the program timeline.

Presentation Number: mat134
Presentation Title: Assembly of Dissimilar Aluminum Alloys for Automotive Applications
Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

Presenter
Piyush Upadhyay, Pacific Northwest National Laboratory

Reviewer Sample Size
A total of four reviewers evaluated this project.

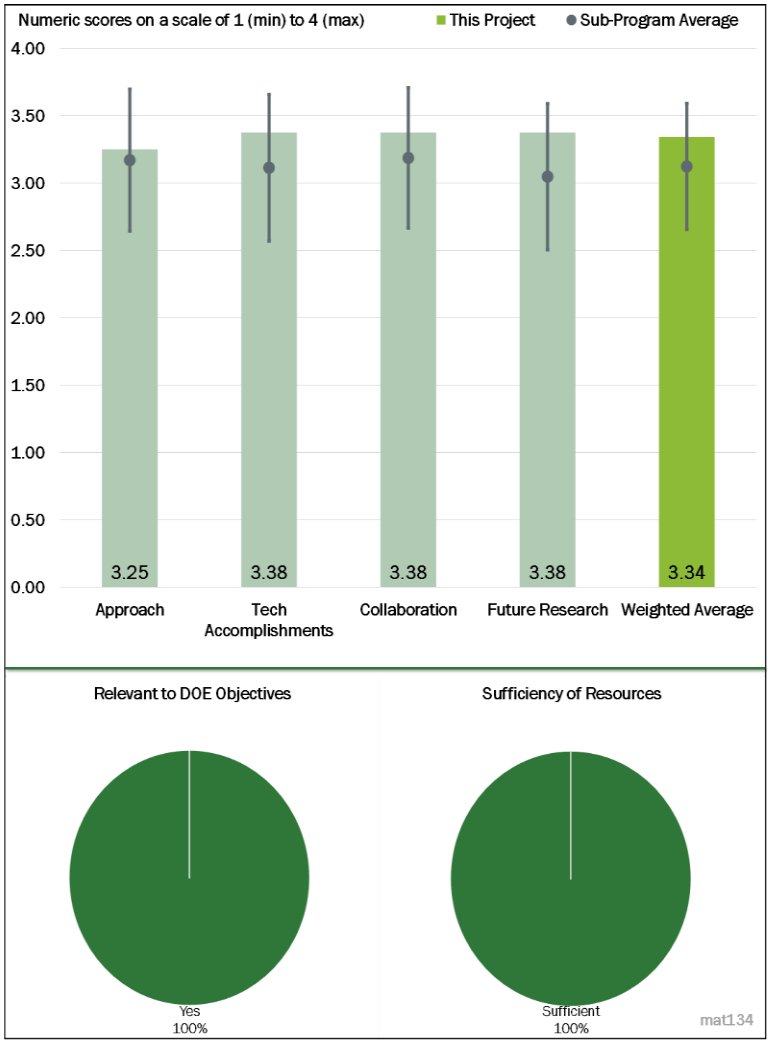

Figure 6-22 - Presentation Number: mat134 Presentation Title: Assembly of Dissimilar Aluminum Alloys for Automotive Applications Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer observed that a very thorough approach was presented for the technical barriers to be addressed.

Reviewer 2:
The reviewer said good approach and recommended that the project team consider a future robotic application.

Reviewer 3:
The reviewer acknowledged that the approach is good, but the comparison to a baseline metal is not convincing and should be addressed by comparing it with other joining methods.

Reviewer 4:
The reviewer referred to a response given in question four. The reviewer asked what the effect is of welding more than half the thickness of the middle layer. This approach not discussed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer was very pleased to see the sensitivity studies on the effects of weld parameters on joint strength.

Reviewer 2:
The reviewer remarked very good progress, the project design is robust.

Reviewer 3:

The reviewer said that the presented accomplishments are good, but as noted, the baseline comparison should be changed. The reviewer also suggested that a more fundamental basis could be provided of why the observed behavior is happening so that this hypothesis can be expanded for further development and application.

Reviewer 4:

The reviewer said that there was not enough discussion on the observed defects so far. The defects have been described well, but discussion could be improved. The reviewer referenced Slide 11 and asked why there is a dip at around 2 m/minute. The reviewer asked what the effect is of welding more than half the thickness of the middle layer, and does it make sense to use as "baseline" the bead on plate weld rather than the base metal as is being done currently. Regarding Slide 13, the reviewer said it was not obvious that the increased hardness arising out of larger welding speed will result in increased joint strength. It would have been nice to have evidence of the same. The reviewer remarked that, as a matter of fact, on Slide 14 the data suggest the opposite. Unless the reviewer is missing something, in the first two rows, the only difference is in speed, but strength is lower at higher speed.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that collaboration appears sufficient to support project objectives.

Reviewer 2:

The reviewer remarked good collaboration between the team members.

Reviewer 3:

The reviewer said it seems to be very good collaboration between the OEM and PNNL, and Arconic is supplying materials and ensuring practical application.

Reviewer 4:

The reviewer noted that conference calls were mentioned, and the reviewer hoped there were also at least a few face-to-face meetings

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that an outline of key activities for future research is very much in line with project requirements.

Reviewer 2:

The reviewer remarked good plan going forward.

Reviewer 3:

The reviewer referenced prior comments that the baseline comparison should be changed and addressed.

Reviewer 4:

The reviewer said that challenges were well-described and captured. The reviewer did not realize until Slide 18 that there had been no integration of the third Al outer layer into the FSW joint. The reviewer inquired if everything reported is for two layers only.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer said that the project directly impacts the knowledge base associated with joining of dissimilar materials.

Reviewer 2:
The reviewer noted how FSW is a significant pillar of future multimaterial joining applications—specifically various grades of Al (5xxx/6xxx/7xxx) and Mg.

Reviewer 3:
The reviewer agreed that the project is relevant to DOE objectives.

Reviewer 4:
The reviewer said that there is a need to be able to use different materials, Al alloys in this case, for lightweighting, as well as to be able to manufacture them rapidly in production.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the project appears to use sufficient resources to support program.

Reviewer 2:
The reviewer remarked the project has sufficient resources.

Reviewer 3:
The reviewer commented resources seem sufficient.

Reviewer 4:
The reviewer said that no data have been presented to indicate that resources are insufficient. The reviewer acknowledged that it is certainly a challenging project with a number of key barriers left, so allotted funds are fully needed.

Presentation Number: mat135 Presentation Title: Technology Validation of Innovative Dissimilar Materials Joining Method in Automotive Production Environment Principal Investigator: Zhili Feng (Oak Ridge National Laboratory)

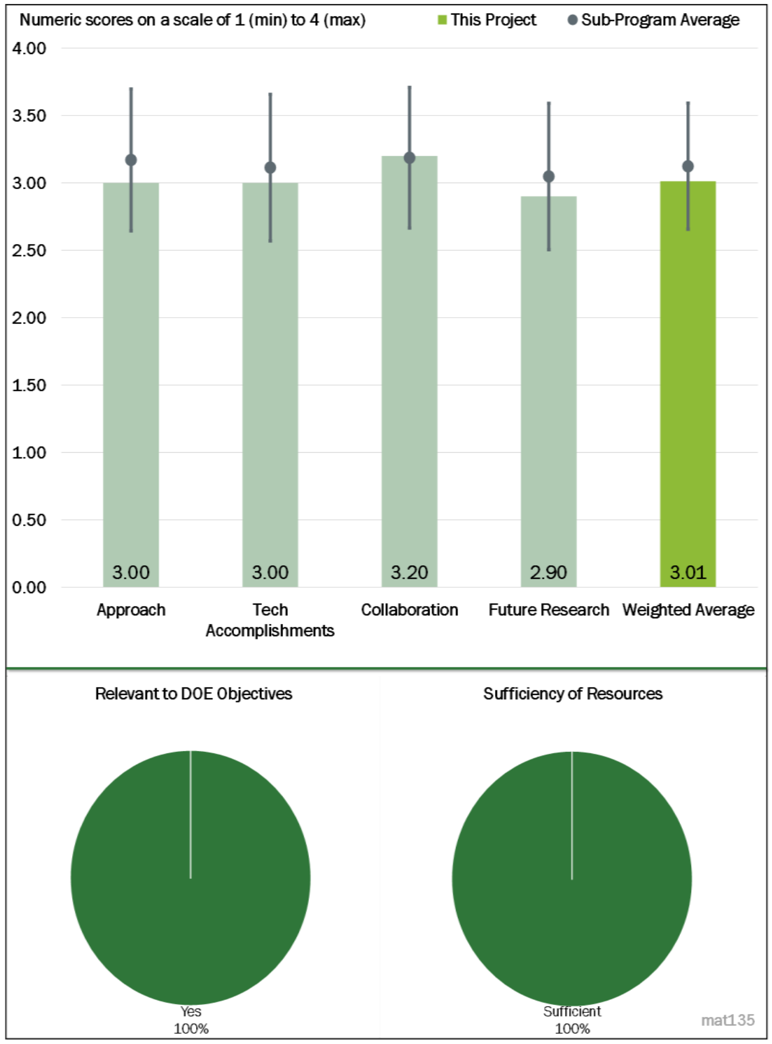

Figure 6-23 - Presentation Number: mat135 Presentation Title: Technology Validation of Innovative Dissimilar Materials Joining Method in Automotive Production Environment Principal Investigator: Zhili Feng (Oak Ridge National Laboratory)

Presenter

Zhili Feng, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer noted that this project is very new. It relies on an older project that the reviewer assumed was successful. The project team is trying to scale up the project from coupon level to sub frame. The reviewer noted that the team has identified a part and have reached a specification for manufacture. At this stage, this seems to be a good plan.

Reviewer 2:

The reviewer remarked that this is a relatively fresh start with 10% completion, but direct pull from a manufacturing operation is a major victory.

Reviewer 3:

The reviewer pointed out that an advantage over a simple drill/rivet operation is not entirely clear, as the bit seems to be a reasonably costly component to sacrifice with each joint. The protrusion of the friction bit joining (FBJ) joint also seems problematic. The reviewer remarked that more background on this would have been helpful. The reviewer noted that a comparison of the lap shear strength with other methods is a critical introductory piece of information, but the project's presentation of this result was rather inadequate. With all of the factors that are relevant to actual joint strength, a straight-line comparison of joint shear strength (reported as a non-normalized force—kN) provides no useful information whatsoever. The reviewer acknowledged having to excuse the project at this point as the work is still early and there appears to be motivated participation from other team members that would indicate the potential value of the process.

The reviewer observed that reporting the bond strength between the bit and the steel substrate is also not overly convincing as to the advantages of the process. The reviewer asked why a relatively high-quality joint from a friction weld between metallic materials would not be expected. The key to this process is the durability of the CFRP or other laminated fiber layer following a rather destructive insertion of a rotating bit. The reviewer noted how the presenter pointed out the necessity of analyzing this quality, but the joint analysis thus far seems to be exactly what would be expected. The reviewer noted how C content in the weld joint due to the CFRP drilling at the tip of the bit may be one item of concern and will also require more detailed analysis.

Reviewer 4:

The one suggestion that the reviewer requested the project team to consider is benchmarking the proposed FBJ versus other known joining methods for the same substrates used in the project. Much discussion was focused on Slide 7; however, there was no basis of comparing FBJ to the other references. The reviewer asked whether FBJ would still show close to two times the performance improvement if the same substrates were used for joining methods in reference 8 and 9. The reviewer also pointed out that the project plan did not specifically mention when the adhesive combination would be evaluated.

Reviewer 5:

The reviewer remarked that the approach is good but it would be good to see more insights into the joint strength comparison to other dissimilar joining methods, interfacial characteristics, issues with CFRP cracking, etc. The approach seems more focused on implementation without addressing or investigating fundamental issues for widespread application of this technology.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked that at this early stage in identifying a part, identifying the specifications of the cell is a good accomplishment.

Reviewer 2:

The reviewer remarked overall, a good start, and detailed that there is key work to be completed, but the parallel paths between process optimization and industrial scale-up seem well crafted. The reviewer cited how the milestones list strongly suggests that the process is now optimized and ready for deployment pending appropriate scale-up trials. The reviewer asked if there are missing data or past work that would qualify this. The testing completed thus far indicates that a milestone or two that evaluates a matrix of process approaches (such as bit geometries or materials systems) would be prudent.

Reviewer 3:

The reviewer noted that much of the technical accomplishments were focused on FBJ. The reviewer asked if the hat sections made will be used for destructive tests. The reviewer suggested the project team please incorporate the evaluation of the hat-section into the project plan.

Reviewer 4:

The reviewer said that the accomplishments are catered to the objectives proposed but lack in providing any advancement in science for broader application of the proposed technology. The reviewer said that a fair comparison to other popular joining methods, tested at similar conditions, would be very helpful.

Reviewer 5:

The reviewer pointed out that it is difficult to access the technical progress without application detail. The application material set needs to be disclosed. The application may be confidential, but public disclosure of the material set is critical.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that the project appears to have sufficient collaboration among members.

Reviewer 2:

The reviewer said good collaboration between team members.

Reviewer 3:

The reviewer reiterated that at this early stage in the project, the team has agreed to a part and has designed a manufacturing cell.

Reviewer 4:

The reviewer said that the program has a good mix of collaborators that provide confidence in the level of motivation behind the work. The reviewer remarked that while it is a novel approach to joining, to the untrained eye it would seem that the structure and protrusions from the joint would be factors that limit interest. The collaboration team (producers/OEM) indicate otherwise.

Reviewer 5:

The reviewer was unsure of the engagement of Hyundai, there was no mention of any interaction.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The future work really builds upon the success of the weld joints thus far—a topic that is arguable at this point based on the lack of useful mechanical property data. The reviewer asked what mechanical testing is planned—or what is relevant that has not been carried out. The reviewer remarked that the shear strength comparison hardly provides enough confirmation of the process.

Reviewer 2:

The reviewer suggested incorporating at coupon or hat-section component level the benchmarking against a few selected known joining techniques. The reviewer also suggested assessing the composite panel damage as a result of FBJ creating a hole. The reviewer pointed out that different composites may show higher sensitivities to damage initiated by drilling into a composite panel. The reviewer said that there needs to be some sort activity that better evaluates the interaction of the composite particles in the joining area.

Reviewer 3:

The reviewer acknowledged that technology scale-up is the proposed future research, but suggested that highlighting any insights from other, prior issues would be helpful.

Reviewer 4:

The reviewer said that insufficient detail was provided to comment on proposed future research.

Reviewer 5:

The outlined future research that will build the cell and test parts will determine the viability of the process at the production level. However, the project team suggested that it will not carry out the corrosion testing. Corrosion could stop this method from going to production

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer pointed out that mixed material joining enables lighter-weight structures. This project is in this area.

Reviewer 2:
The reviewer remarked that the project is definitely relevant to the DOE objectives.

Reviewer 3:
The reviewer said that the project falls firmly into the multi-materials joining category; enabling the joining of dissimilar materials enhances the opportunity for lightweight materials to see increased utilization.

Reviewer 4:
The reviewer commented demonstration of joining CFRP to steel for automotive application needs.

Reviewer 5:
The reviewer said joining dissimilar materials using friction bit in a production application of dissimilar materials joining.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that there appears to be sufficient resources used.

Reviewer 2:
The reviewer found that the team has sufficient resources to implement the project.

Reviewer 3:
The reviewer said that resources seem sufficient

Reviewer 4:
The reviewer remarked that the team has shown that it was able to design a proper cell for manufacture.

Reviewer 5:
The reviewer acknowledged maybe missing something—and asked if all of the funding has been received. The slide shows $633,000 from both VTO and the cost share partner as the total program cost; that same amount was received in 2018. The project runs until 2020. The reviewer asked so is this a $1.3 million project or is it that much per year.

Presentation Number: mat136
Presentation Title: High-Performance Computing and High-Throughput Characterizations towards Interfaces-by-Design for Dissimilar Materials Joining
Principal Investigator: Xin Sun (Oak Ridge National Laboratory)

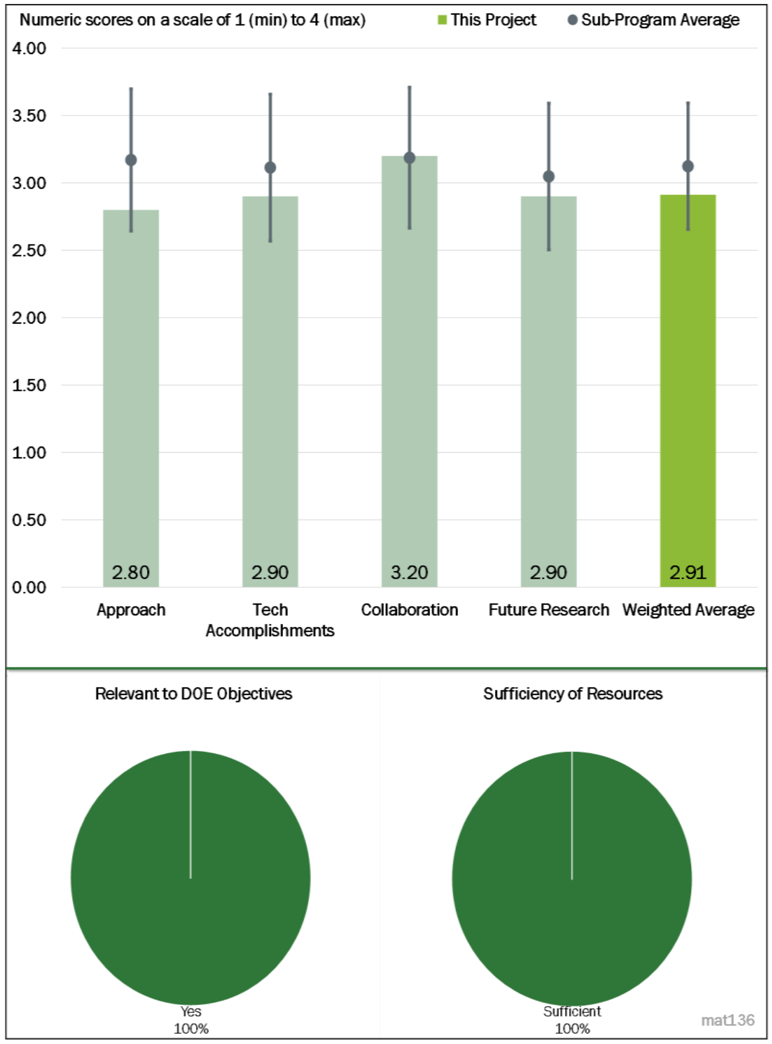

Figure 6-24 - Presentation Number: mat136 Presentation Title: High-Performance Computing and High-Throughput Characterizations towards Interfaces-by-Design for Dissimilar Materials Joining Principal Investigator: Xin Sun (Oak Ridge National Laboratory)

Presenter
Xin Sun, Oak Ridge National Laboratory

Reviewer Sample Size
A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer said that the proposed approach is right on the path to address the observed technical barriers. There is considerable preliminary work conducted that lays a foundation for the proposed work. The reviewer said that the design of work is well established and seems feasible.

Reviewer 2:
The reviewer said that the inverse computational approach is effective to design the process by considering the joint performance, and maybe has less design cycle time compared to traditional computational approach. Also, the multiscale simulation will help explain the physics behind the process and bond formation.

Reviewer 3:
The reviewer remarked that perhaps this has been already addressed, but in the oral or the written presentation, the approach could have been better supported by showing the different phases of the project, how the different phases are tied to the project objectives, the other milestones, and the estimated timeline for studying the key parameters.

Reviewer 4:
This reviewer had trouble following the approach described as “Interface by Design.” The reviewer said that this sounds interesting in principle, but the presentation provided no evidence to support that this “reverse of ICME” can be done simply from data analytics. The reviewer hoped to see more of the “cross-cutting foundational element” demonstrated next year.

Reviewer 5:

The reviewer said that, unfortunately, the project is pretty ill-conceived. Statements such as, there are no proven joining methods for dissimilar materials, is just unfounded (think mechanical fasteners and adhesives), and even for metallurgical bonding (welding methods) many approaches have been in production for decades. Also, according to the reviewer the notion that there is no understanding of the mechanics of bonding for dissimilar metal welds belies 50 years (or more) of literature on the subject. The reviewer understands the project is in the early stages, but an extensive literature review is clearly in order.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer pointed out that the simulations of a few processes have been finished. The results are very interesting, presenting many phenomena that cannot be observed from direct experiments. The reviewer suggested presenting a progress chart, so reviewers could see how the progress goes in accordance with the proposed tasks.

Reviewer 2:

The reviewer said that work has largely jumped to applications pre-selected based on PNNL/ORNL experience (the reviewer inquired where the industrial input is). The reviewer said that the focus is supposed to be defining the interfacial science first, but most of the results are essentially process models and do not address the interfacial science of these joints.

Reviewer 3:

The reviewer failed to see key accomplishments regarding adhesive-based technology and surface morphologies.

Reviewer 4:

This reviewer observed a new project and no significant progress made yet.

Reviewer 5:

The reviewer reported that Slide 7 talks about a future technical accomplishment ("Temperature history will be utilized to perform diffusion and reaction calculations to predict interfacial chemistry and phase composition"). Ideally, these slides should only list the accomplishments that have already happened, and asked whether this was done on Slide 8. The reviewer acknowledged seeing the temperature contours, but was unclear if they have been used to perform diffusion and reaction impacts on the interface. For the two milestones listed on Slide 6, this reviewer inquired as to whether Milestone 1 led to Milestone 2, i.e., whether any data from Milestone 1 was used to establish Milestone 2.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the team is made up of an excellent group of researchers who seem to communicate and coordinate well.

Reviewer 2:

The reviewer noted that the team consists experts from different scales of summations, from molecular dynamics, to macro-scale finite element. Also, the experimental validation is included in the team.

Reviewer 3:

The reviewer said that it would have been great to see where the different expertise exists in the national laboratories and how they are being used to tackle the interface problem, i.e., adhesive interface, adhesive key properties, science of adhesion, etc.

Reviewer 4:

The reviewer said good collaboration between the team members.

Reviewer 5:

The reviewer said that collaborations are between two DOE national laboratories only, no other external collaborators to help “keep the peace.” The reviewer pointed out that cooperative research and development agreements (CRADA) are in the plan (“will be pursued”), but the reviewer asked why not start it already. Generally speaking, interactions between DOE national laboratories tend to be minimal. The reviewer said that in this project, there was no overwhelming evidence to suggest that this is otherwise.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that it will be nice to differentiate the research challenges for FSW and ultrasonic welding because both are thermomechanical processes and share similarities.

Reviewer 2:

The future work references very high-level topics, it would have been beneficial to see a bit more specific details for supporting future work

Reviewer 3:

The reviewer acknowledged this is a new project, so no critical comments. However, as work is planned, it would be great to make a fair comparison on well-established theories in dissimilar material joining that has been done over the past 10 years.

Reviewer 4:

The reviewer said, basically, the rating is based on two bullet points on Slide 11 under “Future work.” The reviewer said this project is a huge challenge with a big ambitious goal, and the reviewer hopes it turns out to be successful.

Reviewer 5:

The reviewer said that this project could use some serious structure. No real plan is laid out, with easily definable milestones and decision points. The reviewer remarked that this project has a “go big or go home” feel, and would be very difficult to manage. It is not clear to this reviewer what scientific paths the team will take to address the basic goals of modeling the interfacial science in order to evaluate\create next-generation process technologies.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer agreed highly relevant to DOE program objectives.

Reviewer 2:

The reviewer said that DOE has a significant interest in developing and validating new-generation dissimilar materials joining processes as a vehicle for creation of multi-material lightweight structures.

Reviewer 3:

The reviewer commented that dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollutions. The simulation can reduce the experimental cost caused by trial and error.

Reviewer 4:

The reviewer remarked very scientific-based approach, much needed. The reviewer is very much looking forward to next year's AMR but perhaps a longer review session than 15 minutes.

Reviewer 5:

The reviewer said modeling and simulation, and using the same is very important, assuming that this interface by design concept can be made to work. The reviewer found that the barriers are well described.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer referenced a prior comment, and said that the project team here is highly qualified and competent. The problem is with the milestones and timing themselves. The reviewer found that resources here are considered excellent.

Reviewer 2:

The reviewer said that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 3:

The reviewer commented that the team has requisite resources to conduct the project work.

Reviewer 4:

The reviewer said that after FY 2019 (Year 2), it may be worth to see if there is sufficient progress in Years 1 and 2 to continue into Year 3. Granted that this is only Year 1, but according to the reviewer progress seems somewhat limited.

Reviewer 5:

The reviewer was not very clear on efficiency of resource utilization as very little information was presented on a comprehensive project plan.

Presentation Number: mat137
Presentation Title: Adhesive Bonding of Carbon-Reinforced Plastic to Advanced High-Strength Steel
Principal Investigator: Amit Naskar (Oak Ridge National Laboratory)

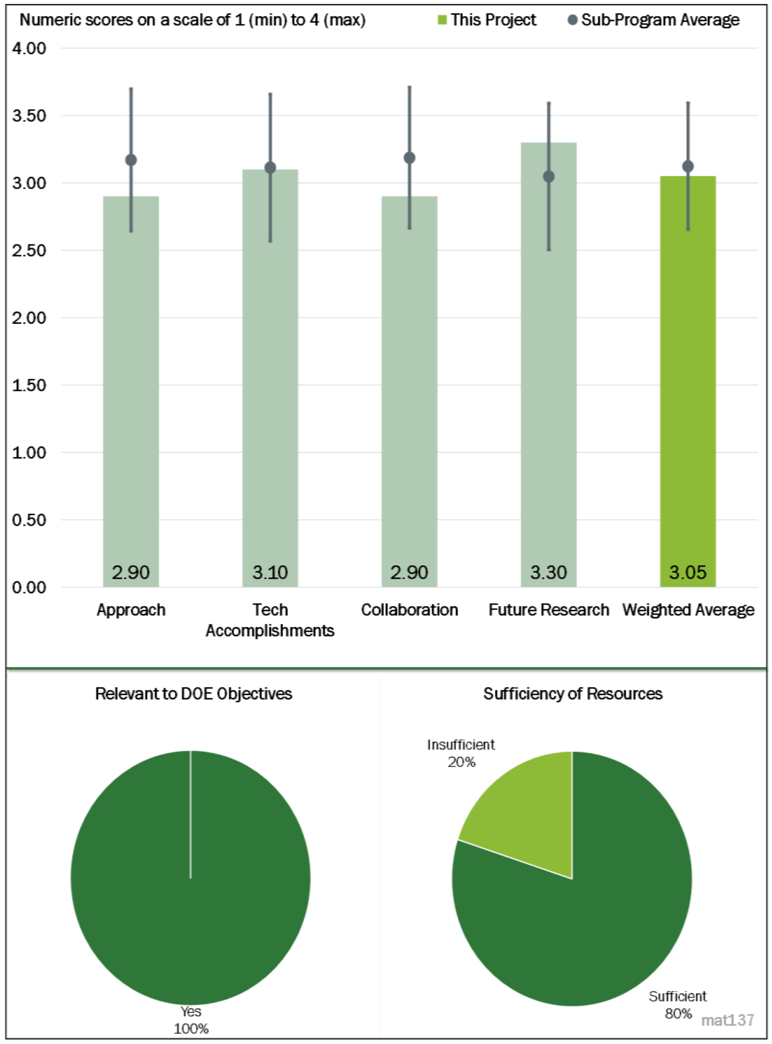

Figure 6-25 - Presentation Number: mat137 Presentation Title: Adhesive Bonding of Carbon-Reinforced Plastic to Advanced High-Strength Steel Principal Investigator: Amit Naskar (Oak Ridge National Laboratory)

Presenter

Amit Naskar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer found that the overall approach is good. The reviewer expressed concern that there is considerable information in the literature on surface requirements for adhesive bonding to both metals and ceramics. A literature review to make sure that the existing knowledge base is covered and considered seems to be lacking. Also, according to the reviewer most adhesive formulations (and the associated chemistry) are extremely proprietary. This was questioned during the presentation, and no way to address this was discussed.

Reviewer 2:

The reviewer noted that the project is new. The approach is well laid-out but it would have been good to know what exact focus the project team is investigating because a lot of work was done in this field.

Reviewer 3:

The reviewer thought there could have been a much better job on articulating the approach. The approach presented is way too general, and not well tied to the overall project plan. The reviewer said it would be great that the project team can present the approach in such a way that is directly tied to the overall project objectives, and delivery against the identified project milestones. The reviewer did not characterize Slide 5 as a comprehensive project approach. Sorry, perhaps the time allocated to review the project was simply too short to better articulate the technical approach taken on the project.

Reviewer 4:

The reviewer said that the proposed approach is very comprehensive. The approaches listed on Slide 5 look confusing. Also, according to the reviewer there are many tests proposed, and it is not clear whether all the tests will be performed (e.g., the surface treatment). The adhesive formulation is controlled by the suppliers, which may raise the challenges in the surface improvement.

Reviewer 5:

The reviewer observed that while the Approach slide (Slide 5) brings out the complexity of the problem well, at the same time, it confuses and complicates the Approach that is being taken. Indeed, it is difficult to even say what the gist of the Technical Approach is. The reviewer said that perhaps the purpose would have been well-served if only some arrows were used to focus on what is being done precisely in this project. The reviewer said that the PI failed to explain the approach clearly and how it would attack the barriers, namely how to join metals to composites.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviver said that the project started this year and is productive considering the given time period.

Reviewer 2:

The reviewer noted that progress has been made, but key elements of knowledge-base capture and adhesive manufacturer coordination have not been addressed.

Reviewer 3:

The reviewer remarked it would have been great if the effect of curing temperature and time, or effect of chain mobility and adhesive bonding, was explained, and how the outputs support the project objectives or barriers. It appears that a bunch of experimental measurements were carried out and specific results reported but nothing else to link how the findings are linked together, how the findings are related to the project plan and objectives.

Reviewer 4:

The reviewer said that this is a new project and commented that prior work and planned outline are well-regarded. The reviewer advised it would be good to compare future results with those already in literature but tested at the same conditions.

Reviewer 5:

The reviewer remarked that the technical Accomplishments slides were somewhat disjointed, more like literature survey results, and very preliminary results on large differences in lap shear tests. The reviewer would have preferred to see more adhesives used on the same material combination, though the differences of the same (?) adhesive on the three material combinations is interesting. The reviewer asked if the digital image correlation (DIC) is being used to measure strain or only the qualitative nature of strains.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that it seems like a good collaboration will be facilitated in the project.

Reviewer 2:

The reviewer said that the collaboration between ORNL and PNNL will fully utilize their expertise and facilities. There are a few tasks indicating that both laboratories will provide the work; however, the role of each party is not very clear.

Reviewer 3:

The reviewer referred to prior comments, and said need to see better collaboration with the adhesive manufacturers.

Reviewer 4:
The reviewer said that there appears to be experimental work that is being completed, but the reviewer did believe there is sufficient interaction among project members to fully understand the significance of the project generated outputs.

Reviewer 5:
The reviewer remarked that it would be nice to see additional industry or academic partners in addition to just the DOE national laboratories. The reviewer did not see any mention of transitions to outside DOE to the automotive industry, for example.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer remarked that the outline for future proposed work is good.

Reviewer 2:
The reviewer said that moving forward, the approaches have merit. However, the background knowledge and manufacturer coordination issues need to be addressed.

Reviewer 3:
The reviewer commented that the work plan is good, but a comparison with the existing work and knowledge base is highly recommended.

Reviewer 4:
The reviewer remarked that the future work captures the research challenges in adhesive bonding of CFRP and metal. The health monitoring in service may take a longer time compared to the accelerated testing, and the one-year period for this task may not be enough.

Reviewer 5:
The reviewer said that the project has only just started, and the challenges are many. The term Interface by Design is used several times without clear explanation. The reviewer said that future proposed work (Slide 14) is really a set of objectives without detail, even in principle, on how to achieve them.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer pointed out that joining of lightweight materials is a foundation to many of the challenges associated with mixed materials.

Reviewer 2:
The reviewer pointed out that DOE has made integration of new materials a key element of VTO. An integration of composites creates focus for this type of work.

Reviewer 3:
The reviewer commented that the dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollution. Adhesive bonding has been proved an effective method to join CFRP with metals, especially the CF-reinforced thermoset composites.

Reviewer 4:
The reviewer said very relevant to the DOE program objectives.

Reviewer 5:
The reviewer commented that the project supports using dissimilar materials and how they are to be joined.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer remarked the team has sufficient resources to investigate the proposed work plan.

Reviewer 2:
The reviewer remarked that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 3:
The reviewer noted that no data were provided to indicate that resources are not sufficient. In projects like these, the objectives and research will be tailored to available funding.

Reviewer 4:
The reviewer exclaimed that the resources are certainly excellent.

Reviewer 5:
The reviewer said that the presented findings portray an image of insufficient use of resources.

Presentation Number: mat138
Presentation Title: Solid-State Joining of Magnesium Sheet to High-Strength Steel
Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Presenter
Piyush Upadhyay, Pacific Northwest National Laboratory

Reviewer Sample Size
A total of five reviewers evaluated this project.

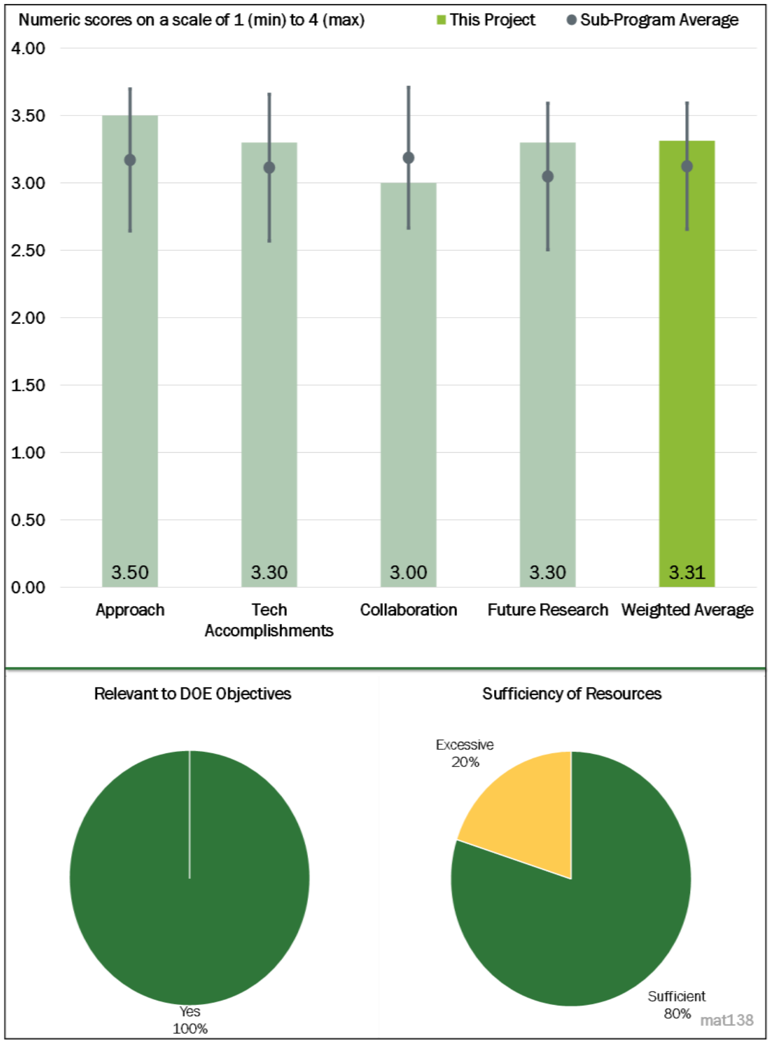

Figure 6-26 - Presentation Number: mat138 Presentation Title: Solid-State Joining of Magnesium Sheet to High-Strength Steel Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The approach is to use advanced techniques to characterize welds made using two different commercially-available methods: FSW and ultrasonic welding. Because these are well-known methods for similar materials, the challenge is to obtain a better understanding of the joining interface for dissimilar metals such as Mg and steel. The reviewer noted that the approach presented addresses joint fabrication, characterization, process data acquisition, fabrication under various conditions, and characterization and analysis of the joint interface. This reviewer found that the approach is sound for obtaining data to overcome some of the challenges of joining these two metals.

Reviewer 2:
The reviewer said that the proposed approach is very comprehensive. It is challenging to tailor the interface through friction stir or ultrasonic welding.

Reviewer 3:
The reviewer remarked that the PNNL team is leveraging and extending work on Al to steel for Mg. The reviewer thought that the approach to narrow it down to two technologies is sound and cost effective.

Reviewer 4:
The reviewer remarked that this is a fairly narrowly focused program addressing two defined technologies. The reviewer may question the technologies selected, but the approach is very good.

Reviewer 5:

The reviewer asked why Al to steel interface not was selected rather than Mg to steel, and whether the correlation of process parameters to interface chemistry is guaranteed, because it is more of an inverse problem. The reviewer inquired if the characterization methods are unique. Researchers do not want a relationship that works only in one specific case with no generality or applicability to another unknown set of parameters. This reviewer is not sure how the observed test behavior is being used by the modeling folks. The reviewer asked if it is a physics-based model that is being tweaked, or a data-fitting model.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The researchers have considerable up-front data allowing the team to formulate good approaches for interpreting performance.

Reviewer 2:

The reviewer pointed out that this is a new start project and is only 22% completed; however, there has been significant accomplishments made toward measuring the microscopic interface and bonding and interface heat generation for the ultrasonic welding process and the friction stir process. Characterization of an interfacial fracture mode has been determined for both methods and interfacial layers have been observed and characterized. The reviewer said that this performance shows great progress towards the objective for a broader understanding of joint interface.

Reviewer 3:

The reviewer noted that the project started this year and is productive considering the given time.

Reviewer 4:

The reviewer said that the project was initiated in 2018 so the majority of work has not been initiated.

Reviewer 5:

The reviewer pointed out that the project is in its early stages, and still establishing methods of measuring process variable. The reviewer detailed that a set of joints have been made for different conditions, but analysis still in progress. The reviewer said that it is difficult to judge if correlation or math modeling has been or will be successful.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that this is an internal DOE project team (PNNL/ORNL) and the team seems to be well-coordinated on this project.

Reviewer 2:

The collaboration between ORNL and PNNL will fully utilize their expertise and facilities. There are a few tasks indicating that the work will be performed by both national laboratories; however, the role of each party is not very clear.

Reviewer 3:

The reviewer noted that collaboration is limited to two national laboratories, PNNL and ORNL. The reviewer suggested that because the research addresses the science behind two commercial methods of joining, there project should also involve industry, either a Tier 1 supplier or an automobile manufacturer or both.

Reviewer 4:

The reviewer pointed out that while very early TRL, it would benefit the team to have two or more industry partners to help guide and establish the materials and performance targets.

Reviewer 5:

The reviewer said that like with other similar projects in this group, it would be nice to also see an industry or transition partner. Right now, it is just the two national laboratories. The dissemination process via papers is much more indirect than having direct partner with regular scheduled interactions.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that this is a new-start project and much of the research is yet to be performed; however, the project is well planned and has a defined schedule of events. The proposed research is in line with the approach to meet the objectives and milestones for the remainder of the project. The reviewer said that alternate development pathways for mitigating risk are not necessary because this project is characterization of welds using commercial methods for dissimilar materials.

Reviewer 2:

The reviewer said that this project is relatively well-defined, and approaches are more focused on interpreting results than developing new methodologies. As a result, the future research approach is easy to describe and comes across as such in both the presentations and discussion.

Reviewer 3:

The reviewer observed that the future work addresses the important research challenges. The coupons for micro tensile test may not be small enough to test the interface mechanical properties. The reviewer pointed out that the joint interface is a complex structure, and it is important to ensure the results are presentative.

Reviewer 4:

It was very difficult for this reviewer to give many details because this was only a 15-minute presentation. The reviewer expected that the team will evaluate a number of failure modes, including TSS, CTS and/or t-peel, which would increase confidence in the process. Additionally, the reviewer said that there should be a stretch joint, i.e., considering Mg to a UHSS of at least 980 MPa.

Reviewer 5:

The reviewer indicated that challenges are somewhat “generic” as described. The reviewer noted that the presentation said, “There is a need to establish effective methods to obtain mechanical properties of interface region,” and expressed uncertainty about what that means, other than “currently we have no idea what to do.”

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer remarked that this project supports an overall DOE objective to improve fuel efficiencies in automobiles through the use of lightweight materials such as Mg and a dual-phase steel. The current high cost of Mg sheet metal and the challenges in manufacturing automobile components with dissimilar materials prevent widespread use of both materials in a single component in the automotive industry. The reviewer said that this project addresses the barriers and challenges of joining Mg to steel by further investigating and correlating process parameters and variables to the weld interface and properties to maximize material properties at the joint.

Reviewer 2:
The reviewer remarked the dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollution. Mg and HSS are two important type of materials for lightweighting.

Reviewer 3:
The reviewer commented this meets the criteria of enabling lower-weight structures.

Reviewer 4:
The reviewer said that the project is only limited by the fact that neither of these technologies is likely to be exploited in any major way in vehicle construction.

Reviewer 5:
The reviewer asked if this (Mg to steel) is more relevant than Al to steel. The latter may be of more immediate importance and applicability to the auto industry.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented the coordinated team is well suited to complete the described scope of work.

Reviewer 2:
The reviewer said that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 3:
The reviewer said, again, no data to suggest that resources are insufficient to meet program deliverables. The reviewer thought that this project might be under the category of fitting the project to existing funding.

Reviewer 4:
The reviewer remarked that while PNNL and ORNL can do all the joining work technically, the team would benefit from consultation with both OEM and materials industry partners.

Reviewer 5:
The reviewer pointed out that this is a 3-year project funded at a total cost of $1.7 million for only two performers, which is almost $600,000 per year or $300,000 per lab. Based on the information presented, the reviewer found that the cost appears to be a little excessive for the type of work (materials characterization) that is being performed.

Presentation Number: mat139
Presentation Title: Joining Magnesium Alloys to Carbon Fiber Reinforced Polymers
Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

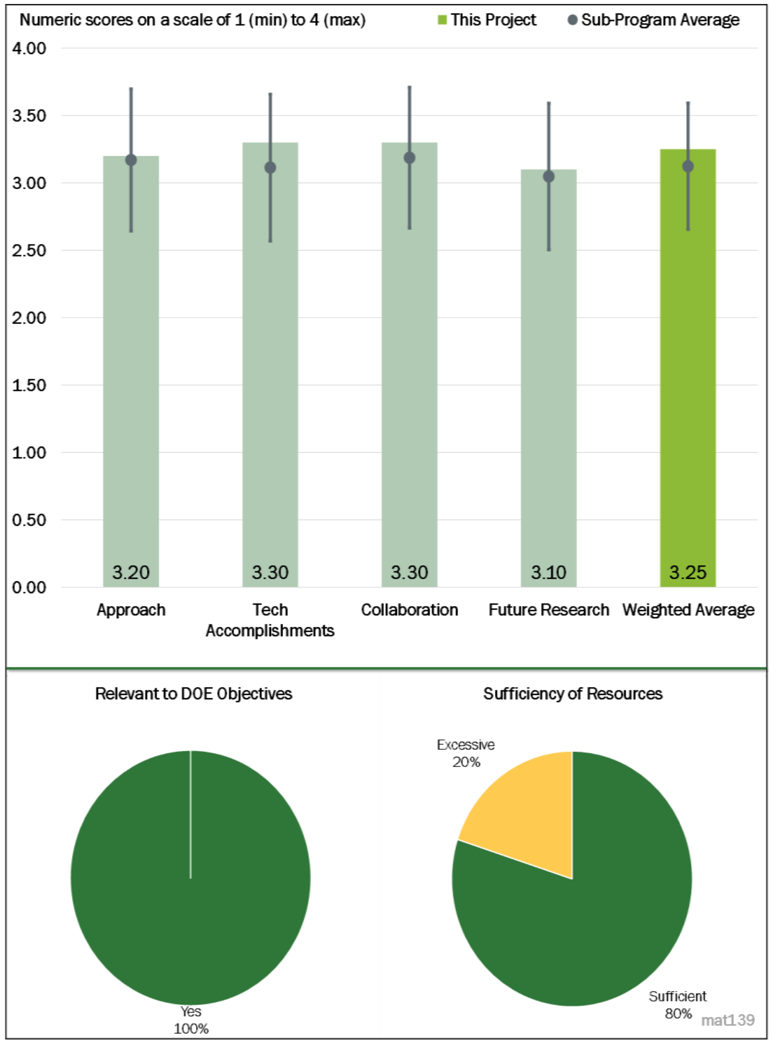

Figure 6-27 - Presentation Number: mat139 Presentation Title: Joining Magnesium Alloys to Carbon Fiber Reinforced Polymers Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Presenter

Darrell Herling, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach addresses the investigation of four commercially available joining methods used mostly for similar materials, but this project focuses on two very dissimilar materials: CF and Mg. The project is well-designed and uses different approaches for each joining method to evaluate and overcome technical barriers to joining metals to composites and also issues of corrosion when these two materials are joined. The reviewer noted that the testing will only involve coupons of joined materials, and nothing was presented regarding component part testing or full-scale testing.

Reviewer 2:

The reviewer found that the proposed approach is very comprehensive. Predrilling holes could be changeling in the real production, especially to drill holes on long CF-reinforced polymer composites. The reviewer noted that the predrilled hole may cause corrosion because the moisture can go inside the holes.

Reviewer 3:

The reviewer pointed out that joining metals to composites is a big barrier, and the approach includes four different methods for down-selection.

Reviewer 4:

The reviewer commented this is an early TRL program with four different technologies being evaluated. Each technology would potentially have its own sweet spot so the reviewer was a little unclear on what defines success. The reviewer suggested the team have target applications and performances defined early to steer the right gauge combinations.

Reviewer 5:

The reviewer remarked the technology focus here seems to be on areas where ORNL and PNNL have some degree of expertise, rather than best approaches for the material combination. A major omission here is adhesive bonding. In addition, the reviewer did not see a difference in approach between thermoset and thermoplastic composites. In the latter case, localized plastic melting has been well-used as a metals-to-composites joining process.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer pointed out that this is a new-start project and it is in the early stages of execution. Consequently, minimal technical accomplishments were presented. The reviewer identified as the most-notable accomplishments that proof of concept and lessons learned have been identified, tensile strength for joints by bolting and FBJ have been characterized, influence of surface coatings have been evaluated, and the design of surfaces features that improve joint strength have been assessed using modeling and simulation.

Reviewer 2:

The reviewer said that good progress has been reported for all four methods with promising emerging results. The reviewer cited a patent application for friction stir interlocking and said that this is a good indication of technical progress and accomplishment.

Reviewer 3:

The reviewer pointed out that to date, progress has focused on understanding/describing the candidate technologies, so any judgement is premature.

Reviewer 4:

The reviewer noted that the project just initiated in 2018 so the majority of work has not been initiated.

Reviewer 5:

The reviewer noted that the project started this year and the team is productive by considering the given time period. It is unclear why the team reported the Al results (Slide 7) because the project focuses on Mg and CFRP.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed a solid technical team with both ORNL and PNNL working with industry suppliers.

Reviewer 2:

The reviewer observed that the collaboration between ORNL and PNNL will fully utilize their expertise and facilities.

Reviewer 3:

The reviewer thought it was good to see industry partners already part of the project, not just PNNL and ORNL as in a couple of other similar projects.

Reviewer 4:

The reviewer pointed out that collaboration involves two national laboratories and two material suppliers: one for the composite and one for the metal. Because this study is investigating the characterization of dissimilar materials joining for four commercially-available methods, the reviewer believed collaboration could be improved if a Tier 1 parts supplier or an automobile manufacturer, or both, were involved in the early design of experiments.

Reviewer 5:

The reviewer said that partners at ORNL and PNNL seem to be well coordinated. The reviewer asked where the industrial partnerships are. The reviewer pointed out that considerable work in this regard has been done by a range of OEM's and Tier 1's.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that this is a new-start project and there is still much work to be done. The proposed future work includes down-selecting joining technologies, maturing those technologies, and incorporating corrosion barrier materials for the down-selected technology(ies). The reviewer noted that no details or milestones were presented to the degree of planning or the decision points that will be used to determine if the results will be successful or will need alternate characterization techniques.

Reviewer 2:

The reviewer said that some research has been done to join Mg with CFRP using ultrasonic welding or friction stir method, which could provide the information to speed up the process down-selection.

Reviewer 3:

The reviewer said that the project's overall direction is very promising. The team would benefit by narrowing the applications in each of the four technology areas to better define the performance requirements and joint specimen types. The reviewer expressed concern that the work shown was on on-lap shear specimen types. Additional work needs to address other failure modes such as cross tension and peel. Additionally, according to the reviewer the impact of adhesives and lubricants used in a production environment should at least be screened.

Reviewer 4:

The reviewer commented, as previously mentioned, this is pretty much a top-down type of project. The candidate technologies have been selected without any real interpretation of the application need nor of the bi-material science implied. This is less science and more technology evaluation, and the reviewer cautioned that the project could conceivably fail to yield any effective solution.

Reviewer 5:

The reviewer asked why FBJ, which was described in another project, not considered here, and if it can be included.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer commented that this project supports an overall objective of DOE to improve fuel efficiencies in automobiles through using lightweight materials such as Mg and CF-reinforced polymers. The current high-cost of Mg sheet metal and the challenges in manufacturing automobile components using a combination of metals and non-metals joined together prevent widespread use in the automotive industry. The reviewer remarked this project addresses the barriers and challenges of joining Mg sheet and CF-reinforced polymers by evaluating four different joining methods.

Reviewer 2:

The reviewer agreed yes, it does, and commented that DOE has long focused on integrating composite solutions into lightweight vehicle designs, so the work described here is pretty mainstream for that path.

Reviewer 3:
The reviewer commented that the dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollution. Mg and CFRP are two important type of materials for lightweighting.

Reviewer 4:
The reviewer stressed that it is absolutely relevant to look at any multi-material joining technologies. The reviewer's only question is why not consider Al to CFRP.

Reviewer 5:
The reviewer was not clear about relevance, although the reviewer assumed that success is finding acceptable performance and cost for at least one of the four technologies being evaluated. If that is the case, then this would be in line with DOE goals to reduce weight and improve fuel efficiency.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 2:
The reviewer commented team has both the right technical expertise and adequate resources.

Reviewer 3:
The reviewer said that no data were provided to suggest otherwise.

Reviewer 4:
The reviewer said that the project seems to focus specifically on technologies where the DOE national laboratories maintain a high-level of expertise, providing sufficient resources for the project's needs.

Reviewer 5:
This project is a 3-year project for $1.8 million with only two performers: PNNL and ORNL obtaining materials from two commercial sources, which is $300,000 per national laboratory. According to the reviewer, this seems somewhat excessive because the project will be evaluating four commercial joining methods, down-selecting to one or two methods, and characterizing the joints from a materials perspective (mechanical properties and corrosion effects). The reviewer remarked that the presenter and presentation does not address component part testing or full-scale testing where the project costs are typically higher and would be in the $2 million per year range.

Presentation Number: mat142
Presentation Title: Metal Matrix Composite Brakes Using Titanium Diboride
Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

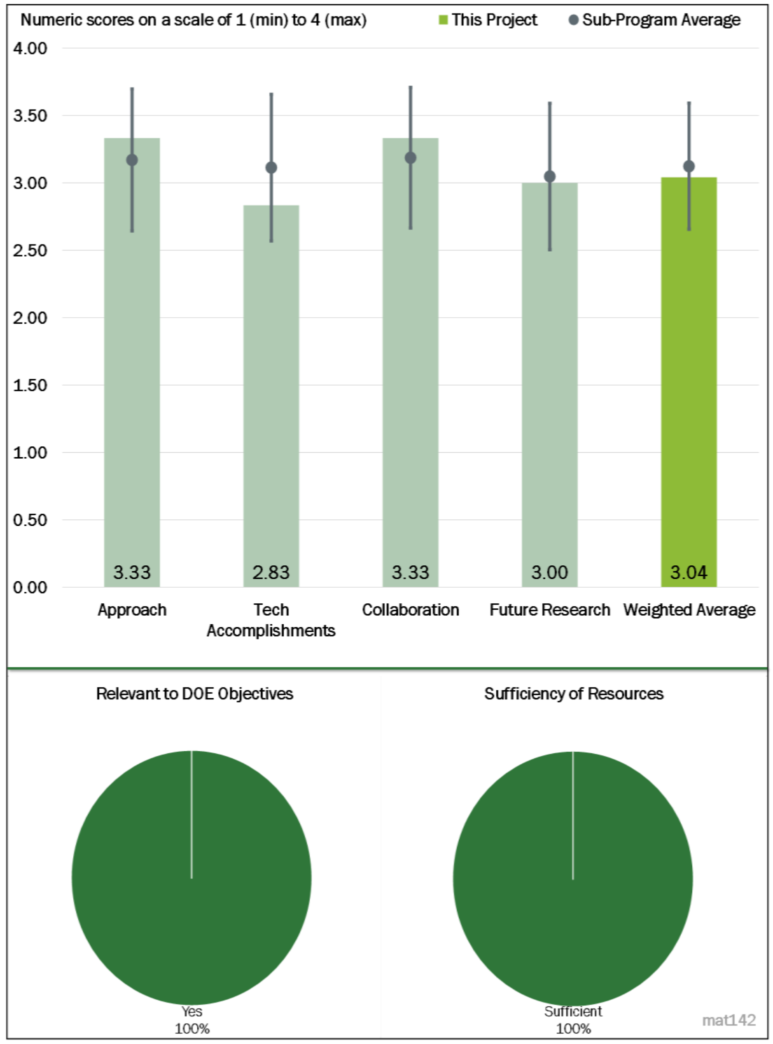

Figure 6-28 - Presentation Number: mat142 Presentation Title: Metal Matrix Composite Brakes Using Titanium Diboride Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer noted that titanium diboride (TiB_2) could be a good reinforcement.

Reviewer 2:

The reviewer said that the approach is well-defined and the objectives are clear—the widespread use of metal-matrix composites (MMCs), despite their plethora of positive attributes for certain applications, remains massively limited due to material/processing/productions costs. Rotors for brakes are both the obvious choice (due to weight savings and wear resistance) and a difficult component to replace (due to the ability to replace cast iron rotors as a consumable at ~$25-$50 per part on the aftermarket). The reviewer found that the approach to re-classify brakes as a "life-of-the-vehicle" component is compelling.

The reviewer detailed that leveraging existing DOE databases from work that was done decades ago is a positive reflection on this program—and clearly shows the value of projects that collect and organize data that can be utilized as a later date. The reviewer remarked it would have been unsurprising for a program like this to suggest that the project team will run extensive testing to baseline known materials, but the team is able to utilize information that already provides that baseline. The reviewer remarked the PNNL role is not overly advanced (nor does it need to be) as the industrial partner is providing a large fraction of the necessary work in material and component production. PNNL has established expertise in the casting/machining that they will be performing. Additionally, according to the reviewer the ability for PNNL to appropriately validate the performance provides a very large level of credibility to any results that are obtained.

Reviewer 3:

The reviewer said that there was no information on the TiB_2 MMC manufacturing process, and there was no discussion about the challenges of getting the desired composition and manufacturing process for optimum brake material manufacture. There are no cost analyses and no unit cost for the TiB_2 brake discs. However, the reviewer noted that the PIs informed the audience that the task is planned but that data are yet to come. The reviewer said that baselining the TiB_2 MMC brake discs (durability, cost effectiveness, durability, etc.) should be carried out using the discs the project team is going to replace, i.e., the cast iron brakes. The value proposition of these new brake discs has to be well defined and explained with supporting data. The reviewer said that the testing is relatively straightforward, so the approach is good. The details of what is to be carried must be well thought out.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer noted that the project started recently.

Reviewer 2:

The reviewer said that the project is still in the raw material production phase, so the technical accomplishments that will be of the most interest to reviewers (or followers of the project) are still upcoming.

Reviewer 3:

The reviewer noted that work is still relatively in its early stages so not many accomplishments apart from raw material processing, tooling, sorting out of some process parameters, etc. However, data should have been presented on the raw material production.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked good collaboration.

Reviewer 2:

The reviewer observed a great leveraging of a motivated industrial partner and a DOE national laboratory—with additional utilization of the LightMAT capabilities. The reviewer pointed out that the program lead is clearly an asset in vehicle-based programs as his practical knowledge of automobiles seems to be as extensive as his materials science knowledge.

Reviewer 3:

The reviewer pointed out that there is only one partner, an industry partner, Arconic. The distribution of tasks seems to be reasonable.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the “meat” of the program is still upcoming, specifically regarding the extensive testing that is planned. How the results will feed back to the manufacturing/production process to provide optimization parameters may also be part of the program, but according to the reviewer the real value will come when the performance measurables are presented.

Reviewer 2:
The reviewer pointed out that the entire work scope, except for Task 1, was presented as future work, which confirms that work is still in the early stages. However, the proposed future work seems reasonable. The reviewer noted that no task was called out for cost analyses (and value proposition assessment) though. The reviewer asked if this task has been lumped together with analyses and reporting.

Reviewer 3:
The reviewer said that a 0.25 mile per gallon improvement may not justify the added cost.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer said that performance enhancement is important.

Reviewer 2:
The reviewer said that the project enables lightweighting of a particular component through materials development and selection. The reviewer noted that the project did an excellent job providing specific energy saving opportunity figures.

Reviewer 3:
The reviewer acknowledged that this question is a tough one. The reviewer wondered if the team is trying to fix an issue that is not really broken or a problem, or whether there is the right value proposition for the discs. The brake disc target weight reduction is 50% compared with steel brakes, so there is a weight reduction advantage (but that remains to be seen). However, the reviewer asked at what cost will these discs be produced. Therefore, cost analyses need to be carried out before this question is fully addressed. The reviewer also pointed out that lifetime durability seems to be the desired target so as to make the value proposition more attractive. The reviewer said that the durability level achieved remains to be seen as well. The value proposition seems to be targeted at electric vehicles (EV) and hybrid cars, so according to the reviewer a value proposition analyses has to take this into consideration; making sure that estimates take into consideration the total number of cars on the roads versus the target market, EV/hybrid cars, and hence overall impact of the new material and discs.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that there seems to be no issue at this time with resources.

Reviewer 2:
The reviewer remarked sufficient resources.

Reviewer 3:
The reviewer found that the resources are adequate—it is not a large project and is more heavily subsidized by the industrial partner than most projects.

Presentation Number: mat143 Presentation Title: Mitigating Corrosion in Magnesium Sheet in Conjunction with a Sheet-Joining Method that Satisfies Structural Requirements within Subassemblies Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

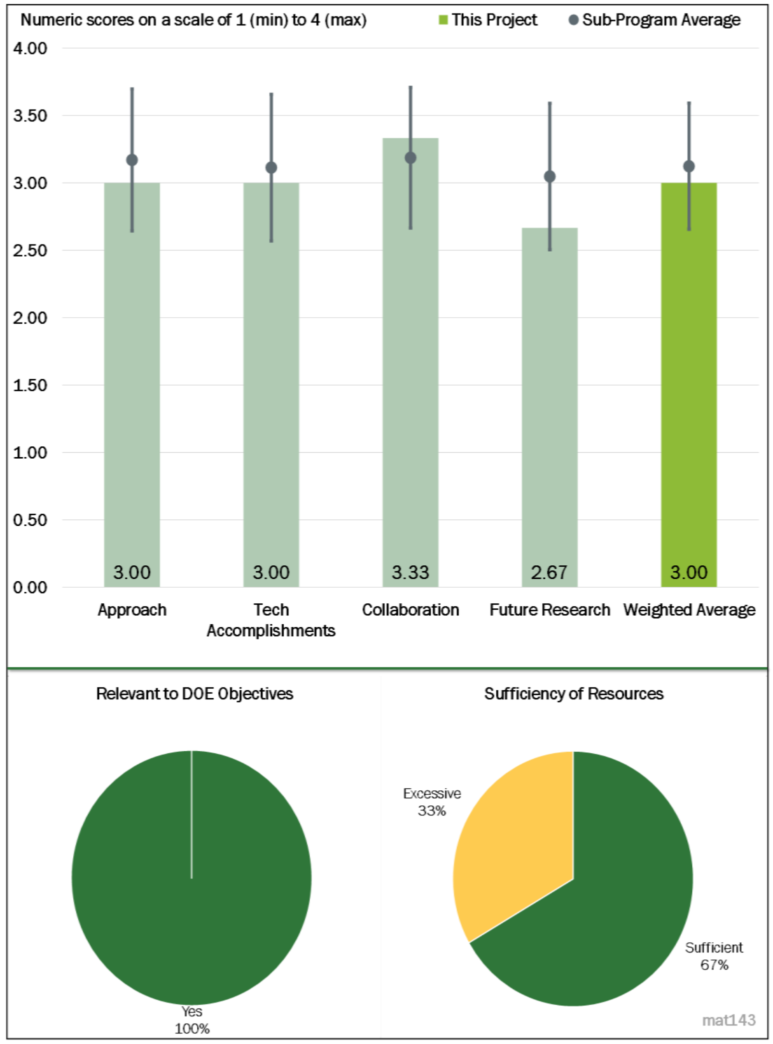

Figure 6-29 - Presentation Number: mat143 Presentation Title: Mitigating Corrosion in Magnesium Sheet in Conjunction with a Sheet-Joining Method that Satisfies Structural Requirements within Subassemblies Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the proposed approach is very comprehensive. According to the reviewer, it might be nicer to consider how to make the corrosion testing consistent, so that it can better explain the results. Currently, it is found the different angles or the locations of the samples will influence the corrosion results.

Reviewer 2:

The reviewer commented that the project is basically a testing project, with no technology development. The reviewer pointed out that Magna is selecting test materials based on their needs, and asked if PNNL is nothing more than a testing lab.

Reviewer 3:

The reviewer did not see this project as providing any solutions, just documentation on the current state-of-the-art. The reviewer acknowledged that corrosion testing of base materials as well as those with simple joints (impulse welds, and mechanical fasteners) will provide data on current corrosion performance, but what kinds of mitigating solutions is the project investing.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

By looking at task/milestone summary on Slide 5, it seemed to this reviewer that an acceleration may be needed to catch up the proposed tasks for this 2-year project.

Reviewer 2:

The reviewer said that the target here is pretty low. Because the researchers will only be corrosion-testing dissimilar material joints with standard assembly processes, progress is made by simply being able to set up an experimental system.

Reviewer 3:

The reviewer noted no major technical accomplishments, but the bar is somewhat low. The corrosion measurement techniques demonstrated in this project do not challenge PNNL's capabilities much beyond that of a test lab.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that because the work is largely driven out of Magna, the reviewer is not surprised that teaming has been effective.

Reviewer 2:

The reviewer thought that it will be nice to give more information on "various Tier-1 Suppliers."

Reviewer 3:

The reviewer reiterated that not much collaboration is required for such a relatively straightforward technical effort.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that microstructures are non-uniform for the dissimilar materials with proposed joining methods. The structure of the bonding interface could be very complicated. These could raise challenges in the investigating effects of microstructures on the corrosion performance. The reviewer pointed out that other factors, such as joint geometry, configuration, and residual stresses, could influence the corrosion behavior.

Reviewer 2:

The reviewer said that testing will answer whatever is currently "unknown." This reviewer is not sure if this is the best use of LightMAT funds.

Reviewer 3:

The reviewer reiterated that this is largely a testing program. The reviewer expressed being challenged by the notion that this project will overcome any barriers. At best, the project will assess potential corrosion benefits associated with contacting surfaces (e.g., joining with mechanical fasteners) and true metallurgical bonds. The reviewer struggled to see what the researchers are trying to achieve beyond this.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer pointed out that corrosion is one of the long-standing make or break questions in a multi-material-vehicle strategy.

Reviewer 2:

The reviewer commented that the dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollution. Corrosion is a critical issue in their applications, and Mg is more prone to be corroded compared to other lightweight metals.

Reviewer 3:

The reviewer said to the extent that the project helps in conveying the various capabilities available in the DOE national laboratories to industry, it supports that objective. The reviewer was not sure how it supports some of the grander DOE vision.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 2:

The reviewer said that the test cell looks nice, and Magna is more than capable of the various joints of interest.

Reviewer 3:

The reviewer thought that industry should bear 100% of the costs of this project, with perhaps PNNL offering some subject matter expertise in-kind.

Presentation Number: mat144
Presentation Title: Reducing Mass of Steel Auto Bodies Using Thin Advanced High-Strength Steel with Carbon Fiber Reinforced Epoxy Coating
Principal Investigator: Dave Warren, Oak Ridge National Laboratory

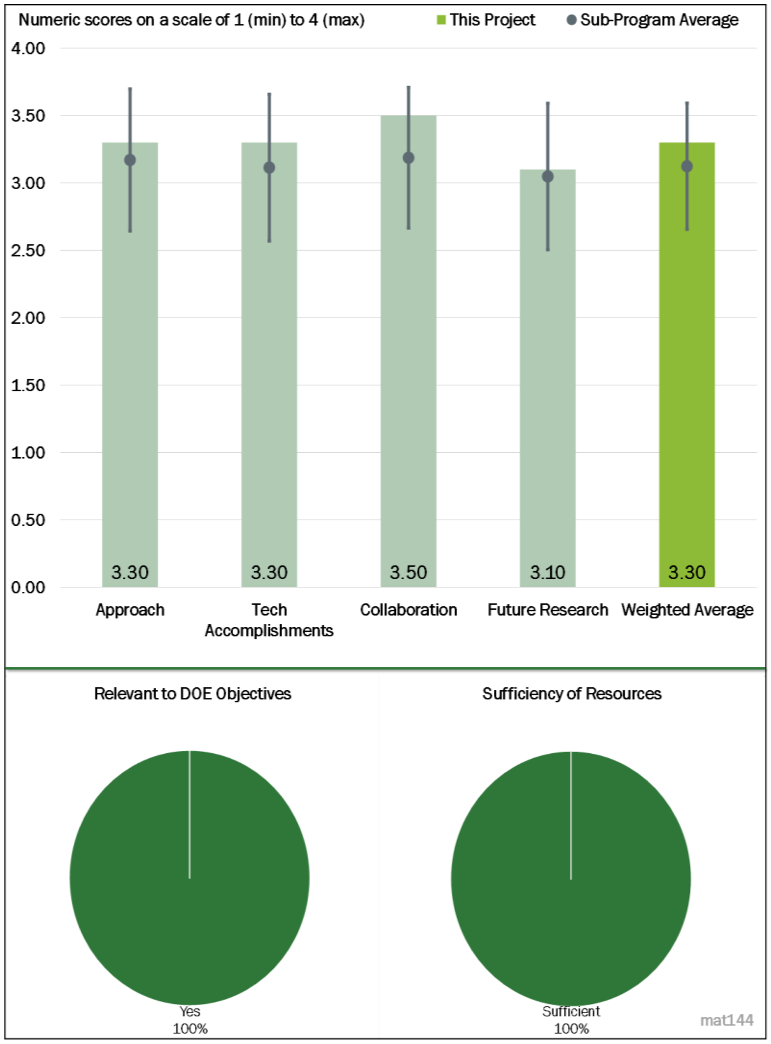

Figure 6-30 - Presentation Number: mat144 Presentation Title: Reducing Mass of Steel Auto Bodies Using Thin Advanced High-Strength Steel with Carbon Fiber Reinforced Epoxy Coating Principal Investigator: Dave Warren, Oak Ridge National Laboratory

Presenter

Dave Warren, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer determined that the project is well-designed and more focused on commercial implementation at coupon and component levels. The reviewer remarked that commercial applicability is very high.

Reviewer 2:

The reviewer said that the approach has a good balance between experimental and simulation. The reviewer would like to see in the future some work on how this would be deployed in production (does it impact upstream/downstream processes) and its cost impact.

Reviewer 3:

The reviewer observed a straight-forward concept that was well-explained and thoughtfully presented. The approach including schedule and milestones are clear and identify tasks. The only comment/question this reviewer has is related to the potential difference in thermal expansion for the two heterogeneous materials that will make up the laminated material system. The question remains: will the project team address the difference in CTE between the steel and C/epoxy substrates. The reviewer said that the build thickness is high enough behind the steel that one would imagine the “bi-material strip” will result in visible deformation through a range of temperatures expected in automotive structure. Thin-gauge steel will undoubtedly exhibit out of plane displacement effecting either appearance or performance (or both). The reviewer said that the approach does not describe requirements or acceptable limits nor any potential issues related to low-cycle fatigue with repeated thermal cycles and the impact on the bond between the steel substrate and CFE. The reviewer recommended that because the economics of this approach to lightweighting are critical to its viability, a simple economic justification for the 15% weight savings should be baked into the project approach to validate cost per kg (lb) of weight saved.

Reviewer 4:

The reviewer said that cost and cosmetic issues are yet to be addressed.

Reviewer 5:

The reviewer commented that the Approach is well-conceived to address the critical aspects of this project. The reviewer would like to also see noise transmission testing in addition to the dent/ding and oil canning evaluations. Including coefficient of linear thermal expansion and corrosion testing ware solid parts of the plan. The reviewer noted that the ELG recycled fiber plus epoxy should increase stiffness. The reviewer asked about the “read through” on the outer panels. The reviewer recommended that given the cost of steel and the cost of epoxy, please address the cost as soon as possible.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer commented that the team is ahead of schedule.

Reviewer 2:

The reviewer remarked that the accomplishments are good for this newly started project. Deciding on the material and process system at this point is a key accomplishment to moving forward with the project.

Reviewer 3:

The reviewer noted that the project started recently.

Reviewer 4:

The reviewer found that technical progress is excellent for a program that only just kicked-off. The project team has been busy and has conducted significant work. The only comment worth considering would be the role of voids in the performance of the system. The reviewer noted how the presenter/PI calls the CFE a “high modulus coating on steel substrates,” according to this reviewer nothing could truly be further from fact. The reported material modulus of 4.5 to 5.0 gigapascal is very low. However, the 0.9 specific gravity is also very low such that relatively high thickness can be added without addition of significant mass. The reviewer said that if this approach is technically and economically feasible, it is because of geometry, not material performance. The reviewer said that void content (air) and resulting build thickness is an important contributor (by the power of 3) to bending stiffness of the section. This may be an important property of the material system, i.e., voids and the resulting impact on cost, bending stiffness, and potential performance challenges such as moisture pick-up and fatigue.

Reviewer 5:

The reviewer noted that results presented indicate concerns with the bubbles appearing in the coating. The reviewer thought that it is good the team realizes this an issue and hopefully the team will overcome this in future to align themselves with the performance indicators.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed good partners.

Reviewer 2:

The reviewer said excellent collaborative partners, and that work is aptly planned between the cross-cutting members.

Reviewer 3:

The reviewer noted a broad collection of industry, including material suppliers and OEMs.

Reviewer 4:

The reviewer noted a well-constructed make-up of the research team. The rationale and contribution of each team member is described and entirely consistent with the research elements and objectives. The reviewer noted that the presentation does not provide insight into the rhythm of meetings, teleconferences, or other design reviews and face-to-face interaction.

Reviewer 5:

The reviewer said that accomplishments to date indicate a great collaborative effort. The reviewer would like to see a matrix of when and who meets by web-based meetings and face-to-face meetings to better understand the collaborations.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that many challenges are to be addressed.

Reviewer 2:

The reviewer remarked that an outline of future work/research is well-described and consistent with the technical requirements of the material system. This reviewer remains concerned about surface distortion as a result of CTE mismatch between metal substrate and CFE. This should likely be evaluated early in the project work so that appropriate actions can be taken to ameliorate any observed effects due to this mismatch and out-of-plane distortion. The reviewer also made a strong recommendation to perform fundamental material cost optimization early in the project to demonstrate/evaluate/report on the incremental cost of materials per unit of mass saved. The reviewer commented that this is very straight-forward and should be used to justify the effort.

Reviewer 3:

The reviewer said that the test plan is clear, but the work would be strengthened with details on how the technology would be deployed in a high-volume automotive environment. Additionally, according to the reviewer the impact of racking on the parts and the potential for delamination will need to be addressed in this project as well (the reviewer noted that the presenter indicated this in fact will be done).

Reviewer 4:

The reviewer said that the proposed future research is good. The reviewer suggested including the NVH characteristics for the outer panel: sound transmission loss, natural frequencies, and torsional stiffness. The reviewer also expressed concern that the epoxy might “peel off” during wind flutter. Please consider checking high cycle fatigue under small amplitude flexing of the panel.

Reviewer 5:

The reviewer said that the team should address the density issue in calculation of mass. According to the reviewer, epoxy and glass/CF density is definitely much higher than what was presented.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer commented that this is a novel and relative simple approach toward significant lightweighting of current vehicle structure; a clearly relevant topic and supports DOE goals and objectives. The reviewer stressed that using an easily applied recycled CF material system to achieve this end is also attractive, and noted that this provides a positive life-cycle benefit for CF and an overall win for reducing embodied energy, another important DOE objective.

Reviewer 2:

The reviewer observed a novel approach to enable downgauging (lightweighting) of sheet. While the research is focused on UHSS, the same principals could be employed on Al or Mg sheet as well. The reviewer noted that the resin and fiber system would need to be changed, but the overall concept could be applied.

Reviewer 3:

The reviewer said that the project is very relevant to the DOE objectives.

Reviewer 4:

The reviewer said that reducing the mass of our vehicles directly supports the DOE objectives.

Reviewer 5:

The reviewer noted that mass reduction through a mixed material solution is valuable.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources are sufficient.

Reviewer 2:

The reviewer remarked team has adequate resources to conduct the proposed research.

Reviewer 3:

The reviewer pointed out that the team is ahead of schedule and project goals seem to be within the bandwidth of the technology.

Reviewer 4:

The reviewer commented at this time, the resources appear sufficient to complete the project on time.

Reviewer 5:

The reviewer said that the objectives of the project are clear, and fairly limited in scope, but provide good value for the dollars spent. While the economic justification remains a bit cloudy to this reviewer, the low-cost research plan and proposed work to be completed should adequately assess the potential for this novel approach of using a combined metallic/non-metallic material solution to automotive panels that require visually attractive surfaces at reduced mass. The reviewer said that resources planned appear adequate to support this plan.

Presentation Number: mat145
Presentation Title: Joining Core Program Overview
Principal Investigator: Richard Davies (Oak Ridge National Laboratory)

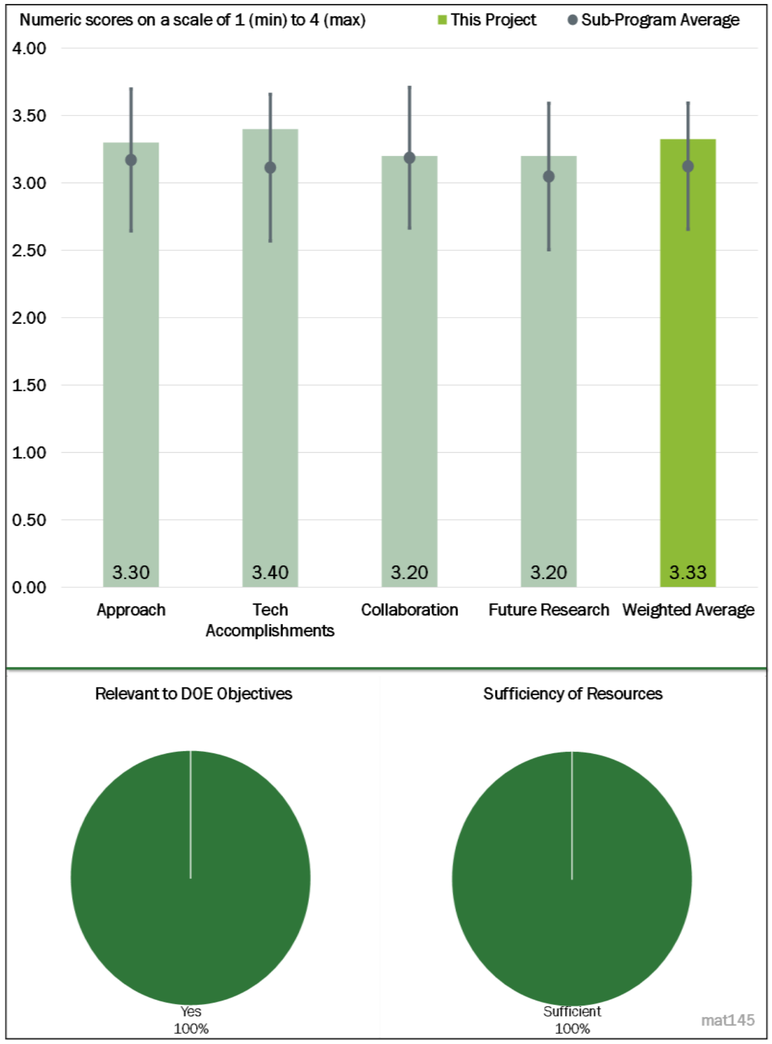

Figure 6-31 - Presentation Number: mat145 Presentation Title: Joining Core Program Overview Principal Investigator: Richard Davies (Oak Ridge National Laboratory)

Presenter
Richard Davies, Oak Ridge National Laboratory

Reviewer Sample Size
A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer commented that efforts to understand the industry drivers and related technical challenges have been shown to be very beneficial in creating a broad program to address the future of vehicle lightweighting.

Reviewer 2:
The reviewer noted how the core program addresses the important research challenges in dissimilar joining. The reviewer pointed out that Al, which is an important lightweight material, could be addressed more in the future research. The corrosion issue in Mg sheets may hinder their applications in automotive applications.

Reviewer 3:
The reviewer said that the approach presented in the core program sounds very interesting. The reviewer expressed being very interested in reviewing the program status at next year's AMR. The only project that this reviewer questioned its value is joining of Mg alloys to CFCs. The reviewer would like to understand better the rationale for selecting the two lightweight substrates, with the question being the likelihood of the need in joining these two specific substrates together versus other options.

Reviewer 4:
The reviewer said that the approach is based on a work table developed by the Materials Technical Team, which needs to be vetted. The reviewer has have never seen a concept for CFRP/Mg nor CFRP/steel nor Mg/Steel. The reviewer proposed CFRP/Al and Mg/Al as the potential application. An MMLV is an application example that is being ignored.

The reviewer said that Mg sheet will most probably be used in a similar application to CFRP, which includes interior body structures not exposed to stone chipping and road sales and not in primary crash applications. The reviewer said that the Mg sheet alloy identified is only available in Korea from primary Mg produced in China using the Pidgeon process. Further, according to the reviewer, AZ31 Mg sheet is only formable at high temperatures in a quick plastic forming operation that requires several minutes per part to form, not applicable to high volume applications. ZEK100 Mg alloy is manufactured from electrolytic ingot in the United States (US Mag) and rolled by Luxfer Group in Missouri. The reviewer said that Mg ingot has a capacity of 100,000 tons/year in coil form, and it is not subject to the $1 per pound tariff. The reviewer pointed out that ZEK100 Mg is $4/lb, and AZ31 around $12/lb. At the time this Materials Technical Team provided input, the availability of Mg sheet from a U.S. supplier (Luxfer) from U.S. ingot (US Mag) was not commonly known.

Reviewer 5:

The reviewer asked to please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them. The reviewer had one overarching comment, specifically, why was Al chosen over Mg in these projects.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer was particularly impressed by how this program overview distilled the key industrial challenges into a number of technology projects.

Reviewer 2:

The reviewer commented that the proposed tasks are on track or finished in advance.

Reviewer 3:

The reviewer commented that it appears the basic framework for the technical accomplishments have a solid foundation to work from.

Reviewer 4:

The reviewer observed excellent progress establishing the focus groups, and the authors just need to redefine the material choices. The reviewer cautioned that following the current material set may not result in a positive outcome.

Reviewer 5:

The reviewer said to please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that efforts have clearly been made to make these drivers the key foci of technology programs. The reviewer noted that integration of DOE only as well as DOE/industry collaboration on these themes is also an effective approach.

Reviewer 2:

The reviewer pointed out that the collaborations are across three national laboratories with industrial suppliers. The unique interface-by-design will facilitate explaining experimental observations and help to design the joining process in a faster manner. The reviewer added that will be nice to demonstrate the results with an OEM.

Reviewer 3:

The reviewer said that from a collaboration point of view, no references to specific adhesive suppliers were made, and the reviewer is not sure whether such references were left out and it was expected to be covered by other subprojects where adhesives were being considered to be used. The reviewer said that the same holds true for composites, the only reference was to BASF supplying thermoplastic plaques. The reviewer asked if this means thermoset composites are outside of the scope.

Reviewer 4:

The reviewer noted how the project team is limited to ORNL and PNNL. The reviewer recommended that there should be an advisory board comprised of industry.

Reviewer 5:

The reviewer said to please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them. The reviewer recommended that in projects where only ORNL and PNNL are partnered, an industry/transition partner is also included.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that future work is discussed in each individual project.

Reviewer 2:

The reviewer liked the planning at this level, but was not as impressed with the organization of the projects that make up the overall portfolio here.

Reviewer 3:

The reviewer noted that many of the projects are new and this is the first year they are being reviewed. However, they all have an overarching framework for future work based on the level of completion of the project.

Reviewer 4:

The reviewer said that the future plan is excellent with the exception of the material set.

Reviewer 5:

The reviewer said please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:

The reviewer commented that the approach presented to cover the key topics at a fundamental scientific level is excellent and it was a much-needed initiative.

Reviewer 2:

The reviewer said that the program is a clear element of the DOE strategy on improving vehicle energy efficiency.

Reviewer 3:

The reviewer commented that multi-material joining is the cornerstone of the future of lightweighting.

Reviewer 4:
The reviewer remarked that dissimilar material joints can save the weight of structure, improve fuel efficiency, and reduce air pollution. The research scope supports the overall DOE objectives very well.

Reviewer 5:
The reviewer said to please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them. The reviewer added that multi-material joining is a huge part of DOE's and the automotive industry's vision for lightweighting.

Question 6: Resources—How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that there appears to be efficient utilization of resources.

Reviewer 2:
As stated previously, this reviewer was impressed with the degree of industry/DOE national laboratory coordination on this effort.

Reviewer 3:
The reviewer noted that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones across three national laboratories.

Reviewer 4:
The reviewer asserted that sufficient resources are deployed.

Reviewer 5:
The reviewer asked to please look at comments for MAT 136, MAT137, MAT138, and MAT139, because this is the overview introductory brief for all of them.

Acronyms and Abbreviations

°C	Degree Celsius
3GAHSS	Third-Generation Advanced High-Strength Steel
3-D	Three-dimensional
AI	Artificial intelligence
Al	Aluminum
AMR	Annual Merit Review
AZ31	Magnesium alloy
C	Carbon
CAE	Computer-Added Engineering
CF	Carbon fiber
CFC	Carbon fiber composites
CFRP	Carbon fiber-reinforced polymer
CGI	Compacted graphite iron
CPEC	Close Proximity Electromagnetic Carbonization
CRADA	Cooperative research and development agreement
CTE	Coefficient of thermal expansion
Cu	Copper
DOE	U.S. Department of Energy
E	Young’s modulus
EM	Electromagnetic
EMN	Energy Materials Network
FBJ	Friction Bit Joining
FLD	Forming Limit Diagram
FSW	Friction Stir Weld
FY	Fiscal Year
GHG	Greenhouse Gas
GM	General Motors

HCP	Hexagonal closed pack
HPC	High-performance computing
HP-RTM	High-Pressure Resin Transfer Molding
ICME	Integrated Computational Materials Engineering
kWh	Kilowatt hour
L	Liter
lb	Pound
LightMAT	Lightweight Materials Consortium
LTC	Low-temperature carbonization
Mg	Magnesium
MgO	Magnesium oxide
MMC	Metal-matrix composites
MMLV	Multi Material Lightweight Vehicle
Mn	Manganese
NCF	Non-crimp fabrics
Ni	Nickel
NVH	Noise, vibration, and harshness
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PDF	Pair distribution function
PI	Principal investigator
PNNL	Pacific Northwest National Laboratory
Pt	Platinum
R&D	Research and Development
RTM	Resin transfer molding
RVE	Representative volume element
SMC	Sheet molding compound
Ti	Titanium

TiAl	Titanium aluminides
TiB_2	Titanium diboride
TRL	Technology readiness level
UHSS	Ultra-High Strength Steels
USAMP	United States Automotive Materials Partnership
V	Vanadium
VTO	Vehicle Technologies Office
YS	Yield strength
ZEK100	Magnesium alloy