6. Lightweight Materials

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance. Because it takes less energy to accelerate a lighter object than a heavier one, lightweight materials offer great potential for increasing vehicle efficiency. A 10% reduction in vehicle weight can result in a 6%-8% fuel economy improvement. Replacing cast iron and traditional steel components with lightweight materials such as high-strength steel, magnesium (Mg) alloys, aluminum (Al) alloys, carbon fiber (CF), and polymer composites can directly reduce the weight of a vehicle's body and chassis by up to 50% and therefore reduce a vehicle's fuel consumption. Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

By using lightweight structural materials, cars can carry additional advanced emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. While any vehicle can use lightweight materials, they are especially important for hybrid electric, plug-in hybrid electric, and electric vehicles. Using lightweight materials in these vehicles can offset the weight of power systems such as batteries and electric motors, improving the efficiency and increasing their all-electric range. Alternatively, the use of lightweight materials could result in needing a smaller and lower cost battery while keeping the all-electric range of plug-in vehicles constant.

Research and development into lightweight materials is essential for lowering their cost, increasing their ability to be recycled, enabling their integration into vehicles, and maximizing their fuel economy benefits.

The Vehicle Technologies Office (VTO) works to improve these materials in four ways:

- Increasing understanding of the materials themselves through modeling and computational materials science.
- Improving their properties (such as strength, stiffness, and ductility).
- Improving their manufacturing (material cost, production rate, or yield).
- Developing alloys of advanced materials.

In the short term, replacing heavy steel components with materials such as high-strength steel, Al, or glass fiber-reinforced polymer composites can decrease component weight by 10-60%. Scientists already understand the properties of these materials and the associated manufacturing processes. Researchers are working to lower their cost and improve the processes for joining, modeling, and recycling these materials.

In the longer term, advanced materials such as Mg and CF reinforced composites could reduce the weight of some components by 50-75%. The Office is working to increase our knowledge of these materials' chemical and physical properties and reduce their cost.

Subprogram Feedback

The U.S. Department of Energy (DOE) received feedback on the overall technical subprogram areas presented during the 2016 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. These questions were used for all VTO subprogram overviews.

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.

Subprogram Overview Comments: Felix Wu (U.S. Department of Energy) - lm000

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

Reviewer 1:
The reviewer observed that the program area was well covered, including the establishment of performance metrics, justification for the focus on materials, identifying the portfolio of lightweight materials, road map exercise and progress to date. The reviewer suggested that some clarification is needed between performance metrics (body, chassis, and interior) when the following slide—for example, "Material Lightweighting: Broad Application"—does not highlight interiors as a focus area. The reviewer added that the "Increasing Focus" slide needs to be clarified as to whether this is a DOE focus or an industry focus, or both.

Reviewer 2:
The reviewer remarked that the sole sub-program goal presented (Slide three) does not appear to link with the Propulsion Materials part of the portfolio. Despite sound strategy materials subsequently presented for each part, this raised the following questions in this reviewer's mind about the overall strategy. The reviewer would like to know why these two categories, what other relevant material classes exist but are not being targeted (the reviewer added that the hallmark of a complete strategy is to say what you are not going to do), and how was the balance of funding/efforts determined.

Reviewer 3:
The reviewer answered no, the presentation did not include a strategy to achieve objective and noted that the focus of the presentation was instead on 2015 accomplishments. Near-, mid- and long-term strategy need be developed for each material system. The reviewer also emphasized that Slide eight needs to be updated, and asked whether glazing, metal matrix composite, and titanium really are the future focus. Finally, the reviewer stated that baseline, near-, mid-, and long-term mass reduction goals associated vehicle subsystem need be established and updated annually.

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

Reviewer 1:
The reviewer replied yes, there appears to be a balance between near-, mid-, and long-term research, although DOE did not describe a timescale in the Overview document. The reviewer observed that automotive experience would dictate that structural, safety related systems would require more long-term research in order to design, develop, and test these applications. The lightweight materials research appears to cover the spectrum of critical challenges described, including items such as predictive modeling, cost, recycling, and improving properties, among others.

Reviewer 2:
The reviewer stated that except for one slide (Slide 15), it was difficult to deduce the targeted timescales from the presented material and thus it is difficult to answer this question. The reviewer suggested more explicit treatment of major targets and time ranges.

Reviewer 3:
The reviewer replied no, remarking that the predominate focus was on past accomplishments. The reviewer recommended that future presentations include more information as to gaps that will be addressed in mid-term and long-term research and development (R&D).

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer answered yes, critical challenges were outlined for each of the material categories and elaborated that challenges described as critical— regardless of severity of the challenge—are still critical, meaning that

they all require some level of research in order to solve those challenges for the technologies to be successful in the marketplace. The reviewer offered as an example that for carbon fiber composites (CFCs), what are needed are nondestructive evaluation (NDE) methods, as well as predictive modeling and low-cost fibers. The reviewer concluded that all of these challenges are required to be solved in order for the materials technology to be successfully implemented into the industry.

Reviewer 2:

The reviewer replied yes, important challenges were identified, but added that they were lost in the clutter of Slide eight.

Reviewer 3:

To reviewer answered to some degree, characterizing Slide eight in particular as a useful catalogue of materials and ranking of challenges. However, the reviewer added that in some cases (e.g., perhaps manufacturing), greater specificity about the identified issues would be helpful.

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

Reviewer 1:

The reviewer replied yes, and elaborated that DOE outlined plans for addressing these issues and challenges based on feedback from, and development of, light- and heavy-duty vehicle roadmaps with plans outlined in three areas. These include properties and manufacturing, which looks to reduce cost of raw materials and processing and improve performance and manufacturing; multi-material enabling, which looks to join dissimilar materials, prevent corrosion, and develop NDE techniques; and modeling and simulation, which looks to develop tools for modeling and accurately predicting behavior.

Similarly, the reviewer observed that DOE outlined plans for the Propulsion Materials Program that also include three areas of focus, namely, Engine Materials, Exhaust System Materials, and Integrated Computational Materials Engineering. The reviewer stated that in both the Lightweight Materials Program and the Propulsion Material Program, demonstration, validation, and analysis are keys to success for rapid acceleration into the marketplace.

Reviewer 2:

The reviewer replied in some cases, yes, but added that the magnitude and breadth of challenges is so broad that it seemed to overshadow the progress of the several worthy 2015 accomplishments. The reviewer suggested that perhaps this is partly a matter of emphasis in assembling the presentation material.

Reviewer 3:

The reviewer judged that the plan to address issues and challenge was not presented.

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

Reviewer 1:

The reviewer replied yes, and recounted that DOE provided five examples of progress made in 2015, including: plasma oxidation technology for rapid throughput of CFCs with reduced energy usage; laser assisted adhesive joining of CF-reinforced polymer (CFRP) to Al; Mg intensive demonstration structure (shock tower); high-strength steel with increased yield; and completed characterization of Mg alloys.

Reviewer 2:

The reviewer answered no, benchmark data was not provided as it need be developed. The reviewer recommended that VTO set mass reduction goals for key vehicle subsystems based on a 2013 model year (MY) baseline high-volume C-segment vehicle to demonstrate the pathway to achieve 30% full vehicle mass reduction as follows:

	Baseline (kg)	Demonstrated	Goal (kg)	
BIW	326	231	162	50%
Closures	98	57	43	56%
Chassis	57	54	31	46%
Bumpers	37	11	11	70%
Total	518	353	247	52%

The reviewer replied no, stating that that there was a considerable amount of recycling of last year's material but in such a way that the reviewer did not get a good sense of continuity or incremental benchmarking. The reviewer clarified that specific accomplishments are naturally highly focused, but to a newcomer, the year-to-year continuity and an overall integrative approach appear to be weaker aspects.

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:

The reviewer observed that VTO is focused on energy security and reduced dependence on foreign oil, and that by focusing on lightweight materials development and usage in the automotive industry, car companies will have solutions in their tool kit to enable lightweight (and safe) vehicles to be produced that will also use less fuel and emit fewer greenhouse gases.

Reviewer 2:

The reviewer replied yes to this question.

Reviewer 3:

The reviewer answered yes, but cautioned that projects need be focused on developing technologies to demonstrate the mass reduction goal for each subsystem.

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

Reviewer 1:

The reviewer replied yes, adding that the program appears focused, well-managed, and effective in addressing VTO's needs.

Reviewer 2:

This reviewer could obtain little insight into the number of current projects, the portfolio balance (other than by financial figures for lightweight versus. propulsion), the strategy relative to time horizons (or alternatively, technology readiness levels [TRL]), or the rationale for the selection or emphasis among individual projects.

Reviewer 3:

The reviewer stated no, the program lacks a clear vision for the future, indicating the need for direction. The reviewer said a budget reduction of 25% is a signal of clarity and a lack of a defined plan to achieve the objective.

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 was unable to provide meaningful comments, partly for the reason cited in the reply to Question 7.

Reviewer 2:

The reviewer stated that the projects are not focused to achieve a common goal of 30% full vehicle mass reduction, adding that if the goal is 30% full vehicle mass reduction by 2020, a roadmap is needed for each subsystem.

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

Reviewer 1:

The reviewer responded yes, characterizing these projects as representing new and innovative approaches to address these barriers. The reviewer declared that gone are the days when a single organization has the capability to fully innovative across the supply chain. The reviewer further remarked that collaboration in the industry has become critically important and helps drive new material development, combined with new processing methods, and combined with new tooling methods, concluding that DOE-funded projects help facilitate these collaborate activities.

Reviewer 2:

The reviewer replied yes to this question.

Reviewer 3:

The reviewer stated that many of the projects are novel and innovative, but are not coordinated to achieve a commercialization objective by 2020, adding that the R&D projects need to be aligned with the needs of the demonstration/validation projects. The reviewer said that several projects specify a vehicle subsystem and a target mass reduction and incremental cost per pound saved are focused and add to the commercialization objective. The reviewer also specified that materials development and joining projects need to specify clear measurable objectives and target mass reduction potential specific to a vehicle subsystem.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said yes, the program actively engages national laboratories, universities, original equipment manufacturer (OEM) companies, tier suppliers, material suppliers, and other research institutes.

Reviewer 2:

The reviewer replied yes, the program seems to have a good mixture of academic, industry, and government research groups.

Reviewer 3:

The reviewer replied yes, but added that there is too much emphasis on partners and instead recommended focusing on aligning and coordinating partners to deliver the commercialized result. The reviewer cited as a good example friction stir scribe technology. The reviewer said the project team includes a hand-off from FRDL to industrial partners to supply commercial application equipment to the OEM/tier community.

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

Reviewer 1:

The reviewer answered yes, the program teams are collaborating well with their partners.

Reviewer 2:

The reviewer replied yes to this question.

Reviewer 3:

The reviewer was unable to say conclusively from material presented, noting that while many other organizations and initiatives were referenced (e.g., MGI, LightMat, the Energy Materials Network, the United States Automotive Materials Partnership [USAMP]), the program's connections to them were not clearly explained for the benefit of outsiders.

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

Reviewer 1:
The reviewer stated that there do not appear to be gaps at this time, adding that the program is taking a balanced approach to solve technical challenges facing the materials industry. The reviewer observed that DOE is funding research in many areas, including reducing costs for raw materials and processing, improving performance and manufacturability, evaluating joining methods for dissimilar materials, developing nondestructive testing methods, and developing tools for modeling and simulation. Continuing this approach across materials solutions provides for a level playing field for suppliers and a broader portfolio of solutions for the automotive industry.

Reviewer 2:
The reviewer remarked that the five 2015 accomplishments in Slides 18 through 22, while technically impressive, appeared to remain some distance from implementation in manufactured, in-service vehicles. The reviewer suggested that because the sub-program has been running for a longer time, it would be valuable for it to track the progressive industry adoption and deployment of previous years' progress, and take some credit for them (as certain other sub-programs appear to do) to avoid any misperception of gaps or any disconnect with commercial relevance. The reviewer was unable to provide further comments, partly for the reason cited in the answer to question seven above.

Reviewer 3:
The reviewer said the gap is the lack of a defined goal, documentation relative to baseline and progress of lightweighting vehicle subsystems. The reviewer offered that there has been significant progress that has not been documented which has led to the reduction in funding.

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

Reviewer 1:
The reviewer replied that technical gaps and challenges identified in industry roadmap sessions appear to be well covered.

Reviewer 2:
The reviewer stated that gaps are being addressed but progress has not been documented.

Reviewer 3:
The reviewer observed that the increased safety challenges associated with lightweighting appear (at least from this overview presentation) to be receiving little attention, and suggested it would be beneficial to have a stronger recognition of that tradeoff (alongside cost, comfort, etc.), than simply having a brief mention on the Summary slide.

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

Reviewer 1:
The reviewer recommended that the program should continue with its balanced approach to solving technical issues across the various material solutions.

Reviewer 2:
The reviewer suggested that given the emphasis being placed on integrated computational materials engineering (ICME) in both this program area and some others, the program might consider pre-competitive funding for better software, following the Computer-Aided Engineering for Electric-Drive Vehicle Batteries (CAEBAT) project approach, so that the "expanded ICME capabilities" referenced on Slide 14 can be deployed more broadly, sustainably, and in a way that directly impacts vehicle manufacturing. The reviewer further noted that presently, the gap in usability between simulating true molecular-scale fundamentals and real processes/vehicle systems is so large that general references to ICME (e.g., Slide 17 title, say) can appear aspirational and insufficiently supported by tangible results.

Reviewer 3:
The reviewer replied yes, noting that reduction of manufacturing cost and life-cycle assessment (LCA) associated with fiber-reinforced polymer (FRP) are not being addressed. The reviewer elaborated that the effort to reduce the cost of carbon has realized the objective but the incremental cost of FRP remains $10 per pound ($10/lb.) mass saved and the carbon footprint is high, prohibiting commercial application. For commercial use, cost per pound saved needs to be under $2.50/lb. The reviewer specified that a benchmark needs to be published for cost per pound saved (e.g., $10/lb.) and LCA along with a plan as to where we are going, adding that if we do not have a plan to realize the commercialization barriers, we need to reallocate funding.

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

Reviewer 1:
The reviewer replied no to this question.

Reviewer 2:
The reviewer recommended that DOE should continue to work with individual companies, industry associations, research organizations, and universities to understand technologies in the pipeline, as well as work closely with the car companies and regulators to understand upcoming needs. The reviewer also suggested that DOE should continue to evaluate short-, medium- and long-term technology solutions, and should do so across the broad portfolio of lightweight material solutions.

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

Reviewer 1:
The reviewer had no other further suggestions at this time, and thanked the program for its efforts and providing a publicly-accessible Annual Merit Review.

Reviewer 2:
The reviewer said improve focus by downselecting carefully from the myriad challenges, which includes everything from materials data to NDE to missing basic material data to manufacturing processes to ICME. The reviewer cautioned that this area seems too broad for maximum effectiveness with the limited available funding and the diversity of vehicle materials. The reviewer offered that focusing on fewer topics might provide greater leadership and progress in those areas and suggested use of a rigorous metric or scorecard to determine what is the low-hanging fruit that gains maximum benefit from this government-led collaboration, adding that perhaps that already exists, but that it was not evident from this presentation.

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 Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis	Powell, Adam (INFINIUM, Inc.)	6-13	3.33	3.50	3.83	3.75	3.53
Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly	Hector, Lou (USAMP)	6-16	3.13	3.50	3.63	3.00	3.36
Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM)	Berger, Libby (GM)	6-19	3.33	3.33	3.75	3.17	3.36
Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator: A Breakthrough Technology for Dissimilar Materials Joining	Daehn, Glenn (Ohio State University)	6-23	3.00	2.88	3.25	3.00	2.97
Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly	Haq, Mahmood (Michigan State University)	6-26	3.38	3.50	3.13	3.38	3.41

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications	Hilty, Robert (Xtalic Corporation)	6-29	3.00	3.13	2.88	3.00	3.05
Vehicle Lightweighting: Mass Reduction Spectrum Analysis and Process Cost Modeling	Mascarin, Tony (IBIS Associates)	6-32	2.58	2.50	2.42	2.90	2.56
Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components	Sabau, Adrian (ORNL)	6-36	3.38	3.00	3.38	3.13	3.16
Brazing Dissimilar Metals with a Novel Composite Foil	Weihs, Tim (John Hopkins University)	6-39	2.90	2.90	2.30	2.80	2.81
High-Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks	Hovanski, Yuri (PNNL)	6-43	3.75	3.63	3.75	3.50	3.66
Upset Protrusion Joining Techniques For Joining Dissimilar Metals	Logan, Steve (Fiat Chrysler Automobiles US LLC)	6-46	3.60	3.30	3.20	2.80	3.30
Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles	Su, Xuming (Ford)	6-49	3.40	3.50	3.50	3.40	3.46

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Predictive Models for Integrated Manufacturing and Structural Performance of Carbon Fiber Composites for Automotive Applications	Aitharaju, Venkat (GM)	6-52	3.50	3.50	3.50	3.63	3.52
E. Coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors	Lewis, Randy (Utah State University)	6-55	3.50	3.43	3.50	3.14	3.42
Solid-State Body-in-White Spot Joining of Al to AHSS at Prototype Scale	Feng, Zhili (ORNL)	6-58	3.25	3.38	3.25	3.13	3.30
Friction Stir Scribe Joining of Al to Steel	Hovanski, Yuri (PNNL)	6-60	3.60	3.60	3.60	3.50	3.59
Enhanced Sheared Edge Stretchability of AHSS/UHSS	Sun, Xin (PNNL)	6-63	3.50	3.50	3.67	3.50	3.52
Optimizing Heat Treatment Parameters for 3rd Generation AHSS Using an Integrated Experimental-Computational Framework	Sun, Xin (PNNL)	6-65	3.00	3.00	2.83	2.50	2.92
Development of Low-Cost, High-Strength Automotive Aluminum Sheet	Long, Russell (ALCOA)	6-68	3.33	3.33	3.33	3.33	3.33

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Overall Average			**3.29**	**3.28**	**3.30**	**3.19**	**3.28**

Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis: Adam Powell (INFINIUM, Inc.) - lm035

Presenter

Steve Derezinski, Infinium, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

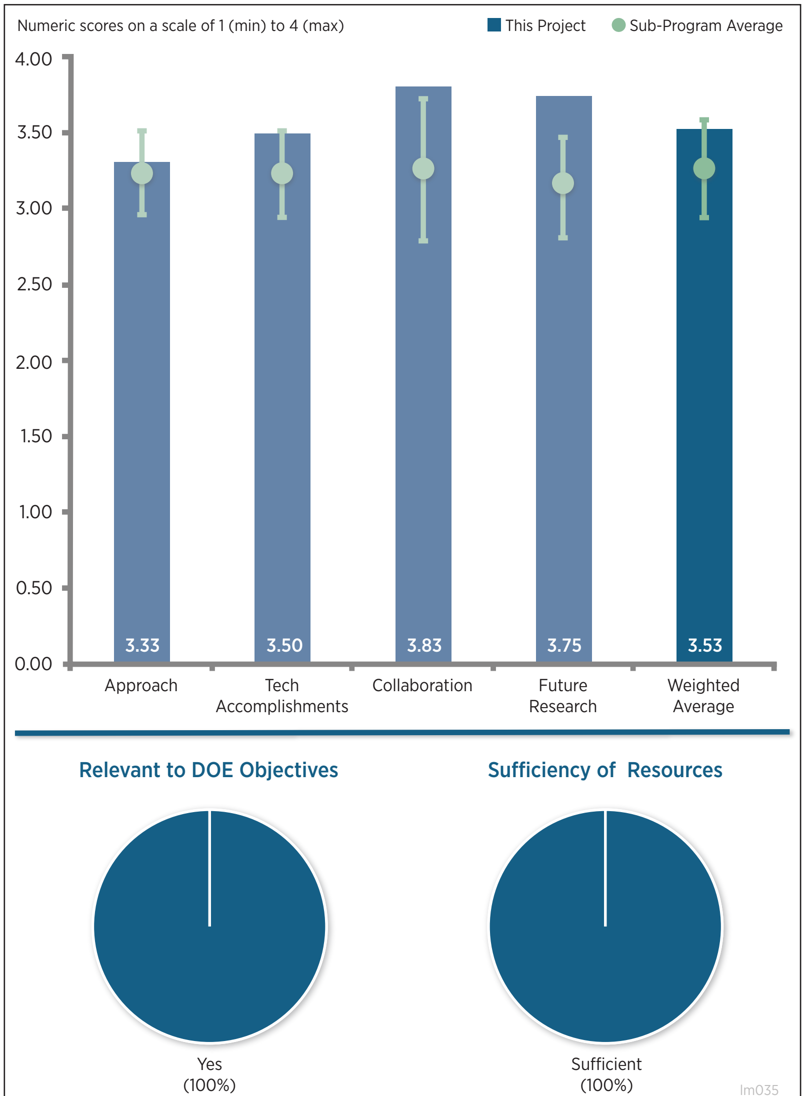

Figure 6-1 – Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis: Adam Powell (INFINIUM, Inc.) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded this as a great project, and clarified that creating master Mg-neodymium (Nd) alloys is a step in the right direction if combining the two parent metal oxides and reducing them is cheaper in the long run. The reviewer remarked that the Mg suppliers could further alloy them into conventional AE42-type alloys, hopefully at less cost penalty.

Reviewer 2:

The reviewer found that the project has shifted from production of a primary metal to alloy seeding, and opined that this was a wise move. The reviewer commented that it is certainly strategic for the U.S./North America market and should result in stronger prospects for Mg deployment in vehicle components.

Reviewer 3:

The reviewer pointed out that the overall goal is to provide an inexpensive and clean domestic source of Mg, yet the program changed to supply a Mg-Nd master alloy. The reviewer was not sure where the change in approach originated from, but it appears to be needed to assist in reaching possible production rates needed for mainstream production. The reviewer was concerned that the rare earth metal availability could be an issue in the future as production ramps up. The reviewer observed that it would be nice to see production rate availability of the rare-earth metal coming from other countries, and evaluate if this supply would accommodate the U.S. demand once production begins.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that there is significant innovation in moving from a primary magnesium oxide (MgO) to a complex MgO/Nd_2O_3 system as a reduction technology to drive the cost out of specialized Mg alloys like AE42, etc.

Reviewer 2:

The reviewer observed great improvements in efficiency in such a short period of time. The reviewer said that compared to current manufacturing processes, it is amazing to see such a high efficiency, and looks very promising going forward. Production rate increases of 10 times from Delta 1 to Delta 1.1 are also very promising to see. The reviewer said that once the gamma cell is running, it will be interesting to see if the efficiencies and production rates meet project goals. The reviewer observed that from an energy consumption standpoint, improvements over current manufacturing processes are very impressive and will assist in process adoption once production rates are up. Environmental impacts just from the reduction of by-products are also amazing, and will enable ISO 14001-compliant companies to further improve the manufacturing impact on the environment. The reviewer cautioned that Slide 11 does not show the efficiency expected from Gamma production; if the efficiency falls off from the newer larger unit, production rates might not be achievable as anticipated.

Reviewer 3:

The reviewer remarked that the shift in project focus/methodology will, understandably, have slowed progress against milestones as new targets are developed. Overall, this person commented that good forward progress appears to have been made. The reviewer concluded that the enhancements to cell efficiency and process safety and robustness (eight hours unattended operation) is very encouraging.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer applauded that this small start-up firm has made collaboration an integral part of their project, and this strategy has worked very well.

Reviewer 2:

The reviewer commented that collaboration efforts have the correct institutions selected, and the collaborators are performing what they do best. The reviewer applauded a great use of resources to focus on each entities' expertise to accomplish a common goal.

Reviewer 3:

The reviewer is hoping to see, during the life of the project, the master 50/50 Mg/Nd soon making an AER42 alloy at a primary Mg supplier.

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 plan looks very good going forward.

Reviewer 2:

The reviewer suggested that as in past years, the project team consider expanding into other rare-earth additional, such as yttrium, erbium, and others.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer emphasized yes, and opined that the project also helps to secure the supply chain for this strategic material (i.e., Mg) in the United States, which is important given the potential difficulties associated with the present supply chain that is based in Asia.

Reviewer 2:
The reviewer commented that Mg is still viewed as an enabling lightweight material for the transportation industry, so this project is well aligned with DOE's objectives.

Reviewer 3:
The reviewer said that with just a pure material swap, Mg has the potential weight savings of over 30%. If successfully able to ramp up production, this effort will enable high-strength castable Mg to be used for automotive purposes.

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 appear to be adequate.

Reviewer 2:
The reviewer commented that the program is wrapping up and should have sufficient resources available to overcome the few remaining barriers and reach the milestones.

Reviewer 3:
The reviewer said that funding is appropriate.

Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly: Lou Hector (United States Automotive Materials Partnership LLC) - lm080

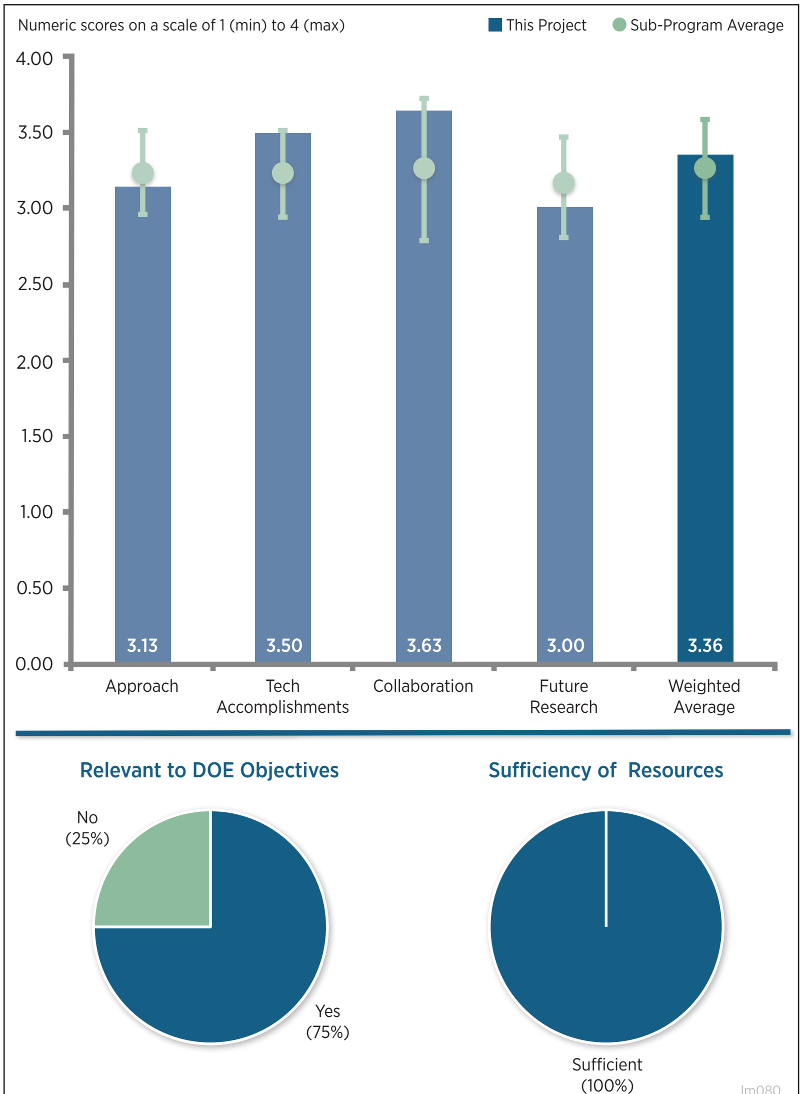

Figure 6-2 - Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly: Lou Hector (United States Automotive Materials Partnership LLC) – Lightweight Materials

Presenter

Lou Hector, USAMP

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, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked excellent approach.

Reviewer 2:

The reviewer said that the approach is leading in the right direction to achieve the goals set forth in the program. Objectives are laid out nicely and a defined path with milestones is in place. According to the reviewer, following what is laid out, if successful, will enable the barriers for third-generation advanced high-strength steels (3GAHHS) to be overcome.

Reviewer 3:

The reviewer observed that this is a very large, complex and challenging project with a lot of moving parts, but it is well-designed, and focused very clearly on the goal of commercializing the technologies being developed. The reviewer stated that the scope and execution are impressive.

Reviewer 4:

The reviewer commented that the mass saving objective was not met. The reviewer commented that an increase in strength will not result in mass reduction in a stiffness driven application, and that no plan to address this topic was presented, significantly reducing the relevance.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer was impressed with the progress and accomplishments to date.

Reviewer 2:

The reviewer said once again, accomplishments and progress toward the goals are impressive. Nonetheless, a lot of work remains.

Reviewer 3:

The reviewer commented that the stated meso-scale model was in agreement with experimental results, but the presentation never identified how closely it meets the objective of validation within 15% of experiments. The new procedure to measure retained austenite would be very beneficial for production purposes. The reviewer remarked that more details about this would be interesting to show the relation between testing and model validation.
The reviewer pointed out that the forming simulation and validation of Task 3 never stated how closely the models were. The project appears to be able to produce the components needed for validation, just need the results and how closely it achieves the goals. The reviewer commented that the design optimization results are very promising going forward and should be able to achieve the stiffness requirements before program ends.

Reviewer 4:

The reviewer said that progress relative to alloy development is very good, but cautioned that commercial application to realize 35% mass reduction may not be achievable. We can replace DP980 with a higher-strength material with increased formability with minimal mass reduction potential.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that collaboration within this project is extensive and appears to be harmonious, productive and worthwhile in the achievement of project goals.

Reviewer 2:

The reviewer applauded great usage of leading experts within the industry to form cross-functional teams. Utilizing cross-functional teams provides a checks and balances for each task and allows each entity to bring their expertise into the project to overcome barriers and reach goals. The reviewer said great usage of collaboration.

Reviewer 3:

The reviewer remarked that the collaboration on coordination is excellent.

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 time did not allow for a full discussion of future work, but it did appear that a good plan has been developed going forward.

Reviewer 2:

The reviewer commented that this is obviously an industry-driven effort, and it shows in the planning. The reviewer expressed concern that this material might be used for conformal hydrogen (H_2) storage on the vehicle. A definitive declaration from the developers on the compatibility with H_2 and natural gas would be useful to avoid a compatibility incident.

Reviewer 3:

The reviewer said that the tasks laid out for the future work will lead to a valid solution and hopefully achieve goals set forth for the project. The reviewer said that very little information was provided about how or what tasks are involved in the model calibration. The reviewer said that this—meeting 15% validation—is a very important aspect of the program, and very little evidence was presented that this goal will or can be met.

Reviewer 4:
The reviewer commented that the plan needs be revised to address the mass reduction potential.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that this activity will help reduce vehicle operating cost and increase safety.

Reviewer 2:
The reviewer said yes, this project is very well integrated with DOE's program goals.

Reviewer 3:
The reviewer said that 3GAHHS will enable DOE goals to be met if this project is successful. Two new materials are already developed that are very close to meeting all DOE goals.

Reviewer 4:
The reviewer said that no mass is saved, and requires heat treatment.

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

Reviewer 1:
The reviewer asserted that resources amazingly appear to be adequate given how big this actually has become.

Reviewer 2:
The reviewer said that the team put together should be able to achieve the milestones laid out. Model calibration could be an issue as newer materials are developed.

Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM): Libby Berger (General Motors) - lm084

Presenter

Omar Faruque, Ford Motor Company

Reviewer Sample Size

A total of six reviewers evaluated this project.

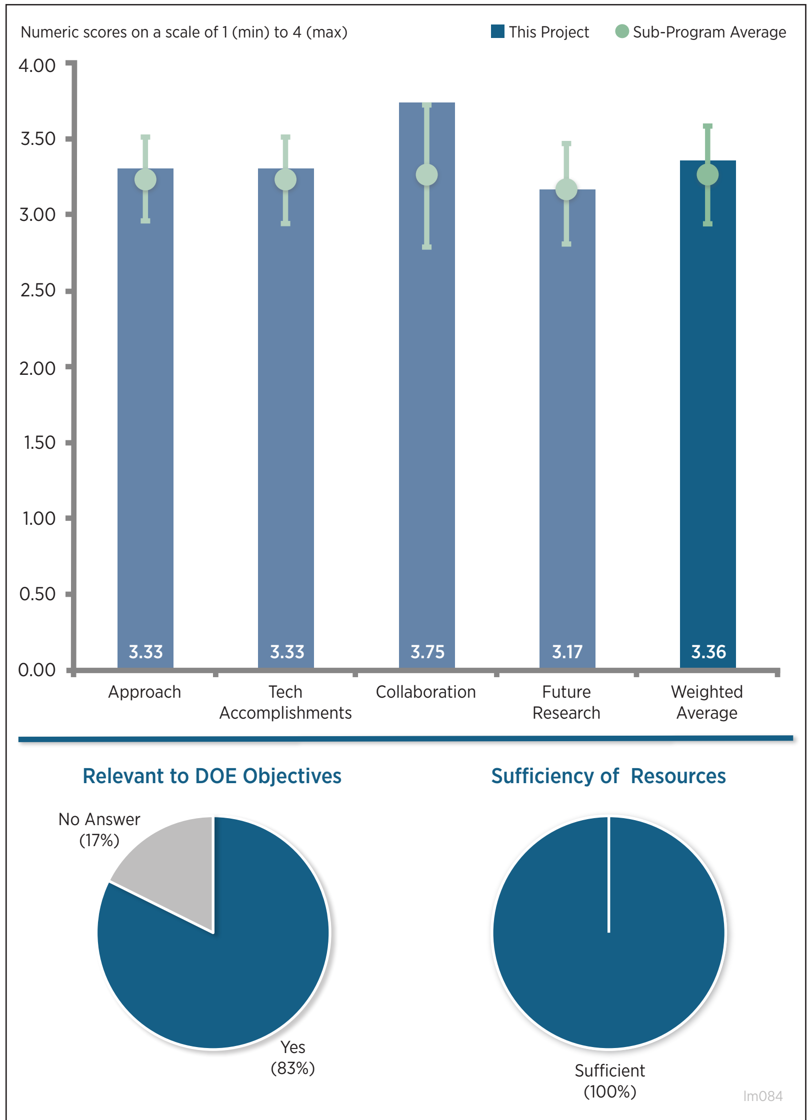

Figure 6-3 – Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM): Libby Berger (General Motors) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach to this work is outstanding. The program team benchmarked a design (steel bumper system) from a current vehicle, developed a new design using composites, manufactured and assembled the new design, tested the bumper system, tested the system using nondestructive evaluation methods, and plans to compare to analytic predictions.

Reviewer 2:

The reviewer said that the approach is good. This person observed that various fabrication and assembly methods to manufacture an automotive component are being addressed and tested as a vehicle subsystem.

Reviewer 3:

The reviewer found that overall, the approach is excellent. It would be good to include manufacturing process simulations in the validation models, not only at coupon level but also at component level.

Reviewer 4:

The reviewer exclaimed that the experimental approach is excellent. The project established the metal values and/or set goals for composites, test composites, and comparison to predictive models. The reviewer noted that the CF processing must be suitable for 100,000/year. The reviewer asked how well results will translate to other geometries and account for other composite manufacturing methods. This person also inquired about the CF tow that was used. The reviewer assumed 12,000, and queried how CF tow size impacts predictive models. The reviewer asked what the ability is to predict 12-layer versus 24 layers. The reviewer observed that parts used were not made with production processes—translation of model validation to production-ready produced components instead of prototypes. The reviewer suggested extending material investigation to include thermoplastic non-woven as an alternative to sheet molding compound (SMC).

Reviewer 5:

The reviewer remarked that the authors have done a comprehensive job in developing a work plan that serves the important purpose of validating dynamic crash simulations against experimental results. The use of multiple manufacturing methodologies combined with integrated bonded assemblies is an important step towards a reliable predictive capability.

The reviewer said that interrogating several different theoretical models and calibrating these tools demonstrates a comprehensive understanding of the range of technologies available and improves the usefulness of this work. The reviewer understood that this cannot be all-encompassing, but commented that the use of quasi-isotropic laminates limits the usefulness of the validation effort. Failure modes have a significant effect on energy absorption and the predictive models must include the physics to capture these effects. The reviewer remarked that the work would be strengthened by acknowledging this and either including experimental and analytical work, or recommending and proposing follow-on efforts to validate predictive models for a range of laminate architectures and failure modes.

Reviewer 6:

The reviewer needed to know a lot more about the joining and highlighted that it was barely mentioned. The reviewer understood that there are intellectual property (IP) issues there, but explained that there are a lot of elements of non-competitive nature and that these should be openly shared.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the technical accomplishments of this project are excellent and make significant progress towards DOE goals. The reviewer summarized the following accomplishments: correlation analysis of baseline steel to predictions; calibration of material models for thermoset materials; calibration of PAM-CRASH MAT131 material model; calibration of Northwestern University microplane material model; University of Michigan drop tower testing for model calibration and joining configuration; ESI predicted NCAP load case for composite bumper system; manufacturable design of composite bumper system; fabrication of composite bumper system; and NDE of adhesive bonding and joints.

Reviewer 2:

The reviewer remarked that the extensive level of work accomplished is impressive. The authors discussed the importance of including the effects of manufacturing variance, but little appears in the work accomplished that assesses the ability to capture the effects of variance in manufacturing within predictive models.

Reviewer 3:

The reviewer said that it appears the project is proceeding as planned.

Reviewer 4:

The reviewer commented that the progress is pretty good, and added that it would be good to include the NDE results in the model validation.

Reviewer 5:

The reviewer listed C-channel; continuous fiber and SMC ribs; and non-primary structure. The reviewer also noted crush cans. The reviewer said that the project contributes to understanding the current codes, but the new project is to validate production components that are cost effective relative to metal options. According to the reviewer, key questions include whether the technology is production ready with predictable results, and whether it can be afforded.

Reviewer 6:

The reviewer observed excellent progress, but expressed skepticism regarding whether the project team will finish as stated. To this reviewer, work remained to be done before the official end of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that collaboration and coordination are well-balanced and coordinated across the supply chain, including with government, industry, and academia. The reviewer pointed out that 14 different companies and organizations were involved with the project. Material suppliers, tier suppliers, and OEMs are involved and contribute to characterization, modeling, testing of the materials, and applications.

Reviewer 2:
The reviewer observed outstanding outreach to partners and other contributing suppliers.

Reviewer 3:
The reviewer said that the project leverages the respective strengths from a variety of competent stakeholders, including OEMs, academic institutions, software developers (to support predictive modeling), Tier 1 suppliers to provide manufacturing support, and material suppliers. The reviewer commented that this was very well done.

Reviewer 4:
The reviewer observed excellent collaboration with university groups. The University of Michigan, Northwestern, and Wayne State were each responsible for unique tasks.

Reviewer 5:
The reviewer would have liked to see more variety among the companies. The reviewer understood that IP issues may be a problem, but at some points, there are a lot of elements that are pre-competitive, and those elements have to be shared throughout the industry.

Reviewer 6:
The reviewer said none.

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 detailed that the proposed future work is very specifically laid out with a completion date targeted for later in 2016 and report writing in 2017. The reviewer noted that completing the bumper system testing, comparing results to predictions, and evaluating thermoplastic solutions and NDE methods are planned for the rest of 2016.

Reviewer 2:
The reviewer thought that the proposed future research was very good, but would have liked to see a future work proposal that demonstrates if the computer-aided engineering (CAE) results apply to other high-volume production processes that have attractive business case relative. The technology will not be used if the other technologies are more attractive. The reviewer said that future work needs to include validation of predictive codes on parts that can be produced at high volume and with attractive business cases.

Reviewer 3:
The reviewer said that the proposed work is responsive to the overall project objectives and is sufficient to meet those goals. As the reviewer noted previously, the overall strength of the project would be improved by evaluating a range of fiber architectures (e.g., fiber dominated and matrix dominated) and shedding light on the ability of predictive models to capture the difference in performance as a function of changing failure modes. The reviewer said that shedding more light on the role of NDE methodologies on predictive analysis and effects of manufacturing variance would further strengthen the value of the proposed future research.

Reviewer 4:
The reviewer said that future work includes only reporting test results. It appeared to this person that there is no follow-on interest. Early stage application like the bumper application are key steps to achieve commercialization, the objective.

Reviewer 5:
The reviewer emphasized that because the project is almost over, it is difficult to assess whether the remainder is good, or better. In the case of this particular project, this reviewer suggested that there should be another option (e.g., Does Not Apply) describing that the project has ended.

Reviewer 6:
The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that the work done on this project is directly applicable to DOE objectives and can be translated to other application areas on the vehicle that can benefit from the strength, stiffness, impact, and lightweighting benefits of thermoplastic and thermoset composites.

Reviewer 2:
The reviewer said that mass reduction is relevant.

Reviewer 3:
The reviewer pointed out that any weight-saving is going a long way toward the DOE goals.

Reviewer 4:
The reviewer said that validating predictive methods, particularly in the simulation of crash events for automotive design, is a prerequisite of incorporating high specific property materials like CF reinforced polymers into transportation systems. Without a high level of confidence in the fidelity of these methods, CF reinforced polymers will not make it onto future platforms. Thus, the reviewer concluded that the overall DOE goals of reducing petroleum based fuel use is predicated on success of this program and others like it.

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 resources applied towards this program are sufficient to complete the goals and objectives outlined in the program. The project work should be completed in 2016 with report writing scheduled for 2017.

Reviewer 2:
The reviewer observed a good number of resources that appear well coordinated.

Reviewer 3:
The reviewer commented that the level of effort, resources expended, and results obtained are consistent. Resourcing appears entirely appropriate for this ambitious and important work.

Reviewer 4:
The reviewer reiterated that when a project is toward the end, there should be a statement of whether there are enough funds to finish the project (how much in dollars).

Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator: A Breakthrough Technology for Dissimilar Materials Joining: Glenn Daehn (Ohio State University) - lm086

Presenter
Glenn Daehn, Ohio State University

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

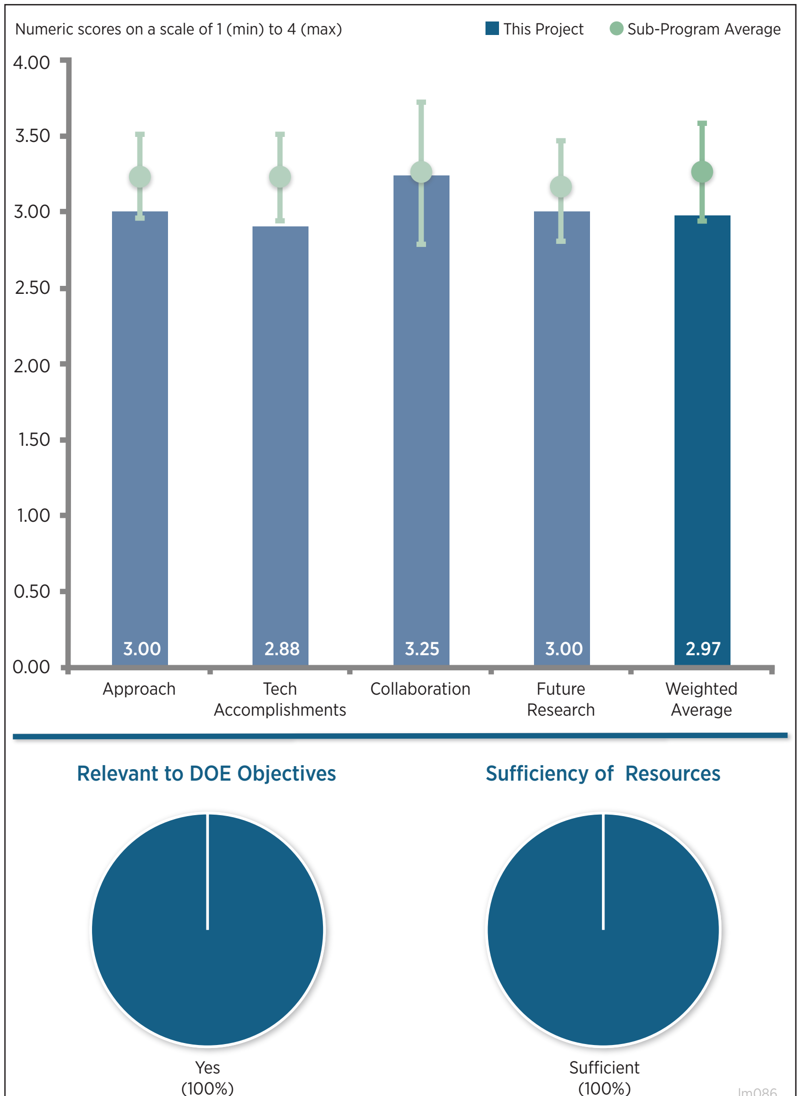

Figure 6-4 – Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator: A Breakthrough Technology for Dissimilar Materials Joining: Glenn Daehn (Ohio State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:
The reviewer observed a good approach at a coupon level to demonstrate feasibility.

Reviewer 2:
The reviewer said that the project shows promise, and a good deal of basic science work has been done, but additional detail on deployment with commercial partners would have been useful.

Reviewer 3:
The reviewer noted an interesting joining technique with very limited applicability. This person opined that there are possible aerospace applications, and expressed certainty that there are no high or intermediate applications.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer observed good progress relative to timeline.

Reviewer 2:
The reviewer remarked that the group appears to have made significant progress toward the project goals and this is commendable. The reviewer questioned how realistic it is to see this process as nearly ready for commercialization. The reviewer thought that a great deal of work on fatigue, corrosion, and joint design will be required before this interesting technology could be used on an actual vehicle. For example, no curved part/joint geometries have been investigated and there are a range of workplace issues such as noise, evolved gas and soot that will require a good

deal of work prior to deployment. Nonetheless, according to the reviewer, this is an interesting and potentially quite useful technology that does warrant ongoing investigation.

Reviewer 3:
The reviewer said that materials systems seem to be randomly chosen with no apparent final application in mind. The reviewer commented that technical accomplishments and progress are good for an R&D project, but observed no real immediate applications.

Reviewer 4:
The reviewer said that it is still not clear how to maintain a one millimeter gap next to welded spots.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that collaboration efforts are good, a pathway to commercialization with an equipment provider and OEM are recognized.

Reviewer 2:
The reviewer said that the issue of interactions was a key concern in the 2015 review, and the group appears to have addressed this and engaged more effectively.

Reviewer 3:
The reviewer observed a good mix of external partners, and suggested a few more from the transportation industry.

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 plan is to continue towards commercial application, and the future is bright for this technology.

Reviewer 2:
The reviewer observed a good plan to continue on the path to a commercially viable process, although the issue of joint geometry needs additional attention.

Reviewer 3:
The reviewer suggested more focus on a targeted minimum joint strength rather than just reporting random and/or various mixed metal combinations. The reviewer reiterated pulling in some industry partners to point the project team to mix materials systems of interest.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that joining dissimilar materials is a core enabling technology for lightweighting vehicle structures, and asserted that the project is aligned with DOE program goals.

Reviewer 2:
The reviewer commented that this technology is an enabler to lightweighting, specifically metamaterial joining.

Reviewer 3:

The reviewer noted the project team's path is relevant as related to mixed metal; albeit high level and loose, it may result in a potential future application.

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 appear to be adequate, including additional investment from the state of Ohio and increased involvement from industrial sponsors (Honda, Coldwater Machine, and Magna International).

Reviewer 2:

The reviewer said that the project is appropriately funded.

Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly: Mahmood Haq (Michigan State University) - lm087

Presenter

Mahmood Haq, Michigan State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

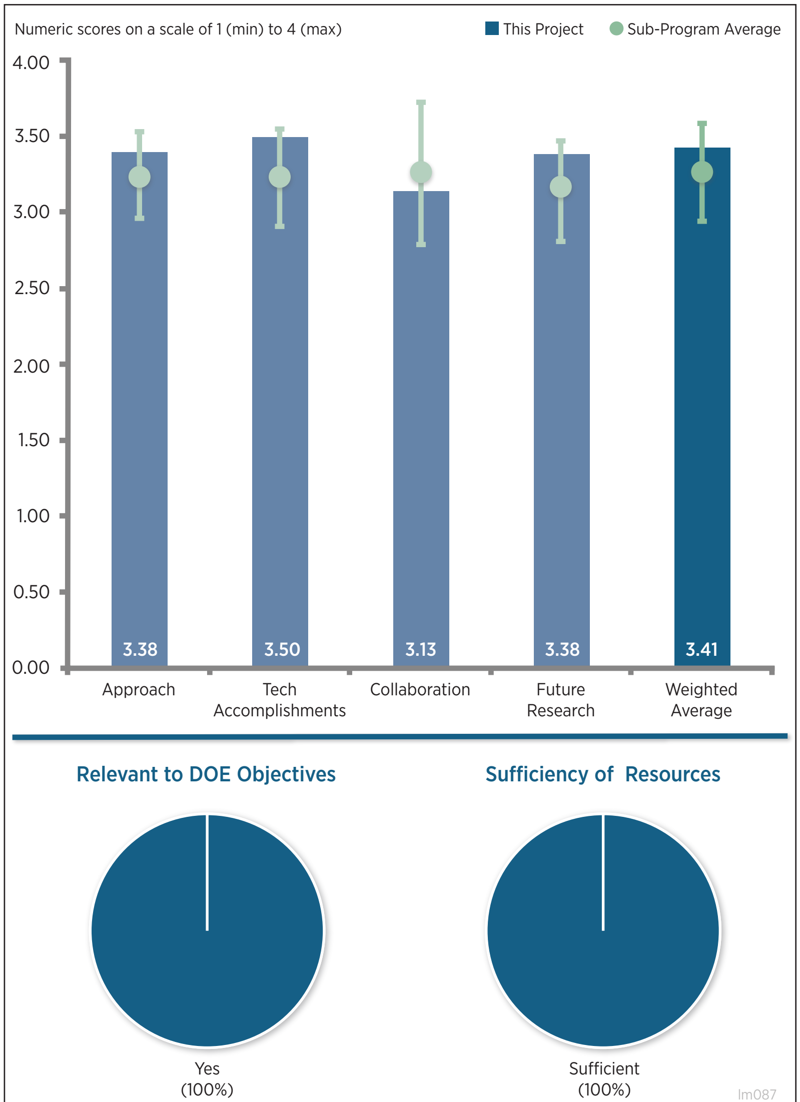

Figure 6-5 – Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly: Mahmood Haq (Michigan State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the overall approach is excellent. This is exciting fundamental work that will have far reaching impact on the composites re-engineering. The reviewer suggested studying the temperature inside the microwave with and without graphene and accordingly make a work plan to engineer the chemistry. The reviewer also suggested investigating the time dependency of melting the adhesive with and without graphene so as to learn the impact of graphene on the bondability of the synthesized adhesive.

Reviewer 2:

The reviewer said that although not specifically identified as an approach, the Summary of Progress on Slide five shows an approach of material development and optimization for a process using thermoplastic and graphene nanoparticles to produce active adhesive pellets and films followed by laboratory evaluations and design tools and database development that can be applied to four different substrates and four different thermoplastic adhesives. The reviewer said that the uniqueness of the approach is in the use of graphene nanoparticles to overcome some of the technical barriers typically associated with bonding metals to composite materials. The milestone descriptions support this approach. The reviewer commented that the results of this research integrate well with other efforts that are currently ongoing to address the technology gaps identified in the EERE VTO Workshop Report titled, “Light-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials February 2013.”

Reviewer 3:

The work being done at Michigan State University (MSU) on reversible bonded joints is very important for the automotive industry. The approach can be better defined in order to improve the understanding of the overall approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that a significant technical accomplishment presented was that the lap-shear strength of a specific functionalized adhesive was improved by more than 30% over a pristine adhesive with only a 3 weight percent addition of graphene nanoparticles. Also, microwave activated joints showed better performance over joints formed with conventional ovens. This resulted in three types of tailorable metal-composite joints that can be bonded, dis-bonded, and re-assembled. The reviewer remarked that this is very significant if the process can be commercialized. The reviewer commented that another significant achievement was the experimental validation of a nano-, meso-, and macro-scale model to predict the structural behavior beyond the experimental results of the project.

Reviewer 2:

The reviewer remarked that excellent progress has been made on this project: addition of nano-graphene particles into thermoplastic substrates and the development of adhesive films; production of various test coupons and joints; evaluation of the results; nano-graphene functionalization has been shown to improve properties; and microwave bonding improves performance versus conventional thermal method.

Reviewer 3:

The reviewer said that excellent progress has been made so far and referenced prior comments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the list of collaborators includes two research and development organizations and an Army activity that is reviewing the project's progress and providing guidance on relevant materials for automotive applications. This reviewer observed no collaboration with supply chain activities where bonding is needed for their products or automotive original equipment manufacturers who would be the technology transfer entities. Although the presenter stated that their input is being incorporated in this project and future work will directly involve them, the project only has one year left and that is very little time to get an automobile manufacture or their suppliers directly involved where they will accept the technology and process being developed.

Reviewer 2:

The reviewer said that MSU collaborates formally with Eaton on this program, but has also directly worked with at least four different automobile companies, many different composite and material suppliers, government agencies, and industry associations.

Reviewer 3:

The reviewer said none.

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:

This reviewer explained that the plan for future work includes corrosion studies, optimization work on processing, thermal testing, re-assembly and repair work, and efforts in NDE. The reviewer commented that additional evaluation on commercialization methods for large automotive applications would be beneficial for this type of joining method.

Reviewer 2:

The reviewer said that the only proposed future research presented was for the remainder of the current research period. The future work described is more upcoming tasks and how they will be accomplished rather than future research needed. This reviewer opined that milestones efforts show that the upcoming work is effectively planned in a logical manner by incorporating appropriate decision points, but do not necessarily coincide with challenges and barriers pointed out later in the presentation. The reviewer said that some significant challenges are addressed, such as processing problems with thermoplastics and equipment needed to handle larger sample sizes as would be the case with industrial applications.

Reviewer 3:

The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the work being done at MSU on reversible bonded joints is directly applicable to DOE's goal of building lightweight vehicles and enables the use of multi-materials by automotive companies.

Reviewer 2:

The reviewer observed that Slide four of the presentation showed eight key technical gaps for light-duty vehicles systems that this project addresses directly. These include lack of technology and fast, robust, and reliable processes for joining dissimilar materials; lack of modeling, simulation, and predictive engineering design and modeling tools; lack of high-volume manufacturing capacity; and design knowledge and databases, which are contained in the Office of Energy Efficiency and Renewable Energy (EERE) VTO Workshop Report titled, "Light-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials February 2013."

Reviewer 3:

The reviewer said absolutely, because composites repair is a growing need for a futuristic transportation sector that has started to advocate composites in the mainstream.

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 this is a three-year research project to improve a bonding technique for $600,000 ($200,000 per year average). All previous milestones and go-no go decision points have been successfully met on schedule with the funding provided with only three milestones to meet in the final year of the project. The reviewer commented that the project is well managed and, when received, funding (approximately $263,000) will be sufficient to achieve the stated milestones.

Reviewer 2:

The reviewer said that the resource levels for this work appear appropriate for this project. Additional work and a future project(s) could branch from this work.

High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications: Robert Hilty (Xtalic Corporation) - lm089

Presenter

Robert Hilty, Xtalic Corporation

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, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the approach is good, and emphasized that the change to clad onto traditional sheet is key to the cost/benefit relationship. This person further noted that the true application is thin layer, but the funding opportunity announcement topic forces to thick layer.

Reviewer 2:

The reviewer said that this looks like a really interesting project on an important issue, but the reviewer admitted that the feasibility of the plating process to build up a structural element is new. The reviewer suspected that a lot of testing will need to be done to establish this technology.

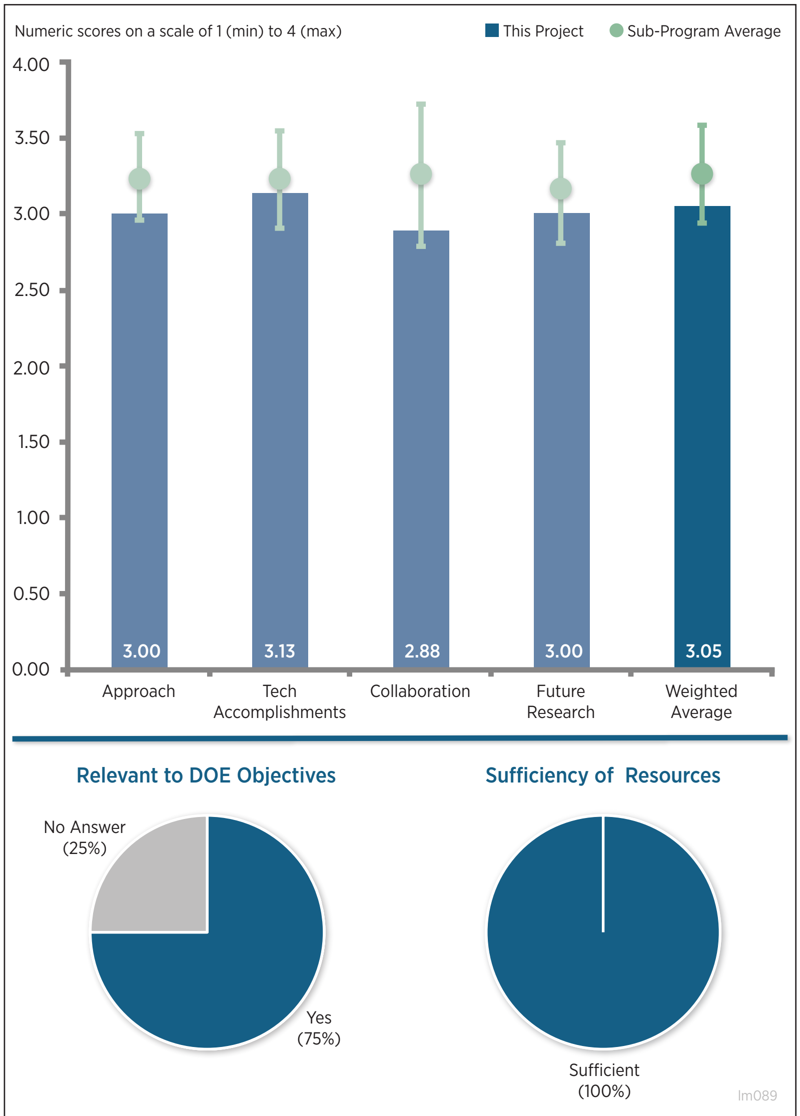

Figure 6-6 – High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications: Robert Hilty (Xtalic Corporation) – Lightweight Materials

Reviewer 3:

The reviewer commented that manufacturing advanced materials is said to be a barrier, yet the approach starts with a current material and makes it better to meet an end goal. While this approach should meet final project goals, this is not a new material, only a surface treatment. Cost is also a barrier defined by the project, yet starting with a thin rolled product caused this reviewer to think the process is inherently more expensive because the starting material would be more expensive. Every reduction in thickness of a rolled product increases product cost. This just seems to contradict general manufacturing rules as the proposer states a layered structure improves cost without sacrificing performance. The reviewer added that the use of go/no-go is acceptable.

Reviewer 4:

The reviewer said that the approach is good for this stage. However, the reviewer wanted to see more information on potential methods to scale up this technology to large volume production. The reviewer said that the efforts on the sheet/plating work appears solid for this project. Further, this reviewer indicated that the manufacturing time sounds good.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented on-time with progress.

Reviewer 2:
The reviewer explained that it appeared that good progress has been made against a number of key goals, but it appeared that a good deal of work remains, including cost modeling, thermal stability in coatings processes, and perhaps some work in design variables that will be required for modeling of actual vehicle parts.

Reviewer 3:
The reviewer observed great progress on plating development for deposition layers and finding possible additives to overcome the dendrite formation and increased layer thickness. The reviewer expressed some concern about moving from rods to sheet and still meeting the project goals. The reviewer asked whether the machine places the final thickness in one pass through the bath, multiple passes are required to increase thickness, or the process just needs to slow down through the bath to increase thickness.
The reviewer commented that Slide five shows a stress/strain curve that appears to meet DOE goals with an AA6061 inner layer, but Slide 12 shows the test ran on AA3104. There needs to be a defined path for what material/materials are the substrate and what materials will meet or exceed goals.

The reviewer said that process control development is coming along nicely, though there is concern on the nondestructive testing (NDT) method presented. The current NDT method allows for 100 µm thickness to be measured, yet the end product will have a thickness layer greater than 400 micrometers. The reviewer said that the presentation showcased a continuous electroforming system to develop six-inch wide samples. The reviewer remarked having a hard time believing a six-inch wide sample will have much usage in the automotive world other than for a few possible applications. The reviewer said that only a rear door side impact beam was shown as a possibility, and this seems like a lot of funding and development for just one part. The reviewer suggested possibly identifying multiple possibilities and parts where the technology can be used.

The reviewer reported that the cost model has been built and will be used to identify best opportunities to reduce manufacturing costs. However, the models were not available for review, which led the reviewer to question the process expense and how close goals are to being achieved.

Reviewer 4:
The reviewer described the strength as great, and expressed hope that the project team can get the ductility to where it is wanted for high formability. The plating results are great and are cautiously optimistic. This reviewer asked if there are any corrosion concerns.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that collaboration appears to be good.

Reviewer 2:
The reviewer observed great collaborators, solid division of assignments, and clear roles and responsibilities.

Reviewer 3:
The reviewer commented that partners meet the minimum needed to accomplish goals. The team will be able to meet the goals as they are laid out.

Reviewer 4:
The reviewer said that the project does not require significant collaboration.

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 plans going forward appear to be realistic and focused on the goal.

Reviewer 2:
The reviewer said that future work is to demonstrate feasibility, and that starting with sheet substrate is a very positive change in approach. The reviewer recommended that a lifecycle analysis needs be conducted. The side door beam may not be the target application, but due to roll width constraints and acceptable proof of principle.

Reviewer 3:
The reviewer wanted to see more details on the next steps, as well as how the cost model and cost estimates will be done and hopefully influence future plans. The reviewer commented that the efforts on the wider sheet will be a good addition.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer asserted that high strength, high ductility Al enables lightweight vehicles.

Reviewer 2:
The reviewer indicated that Al is clearly an important material at present and, if cost, strength, and predictability constraints can be addressed, it has a very promising future for wider application in lightweighting vehicles. Thus, according to the reviewer, the project is definitely aligned with DOE program goals.

Reviewer 3:
The reviewer commented that the real application is Al deposition on Mg substrate.

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 that resources look to be okay.

Vehicle Lightweighting: Mass Reduction Spectrum Analysis and Process Cost Modeling: Tony Mascarin (IBIS Associates) - lm090

Presenter

Tony Mascarin, IBIS Associates

Reviewer Sample Size

A total of six reviewers evaluated this project.

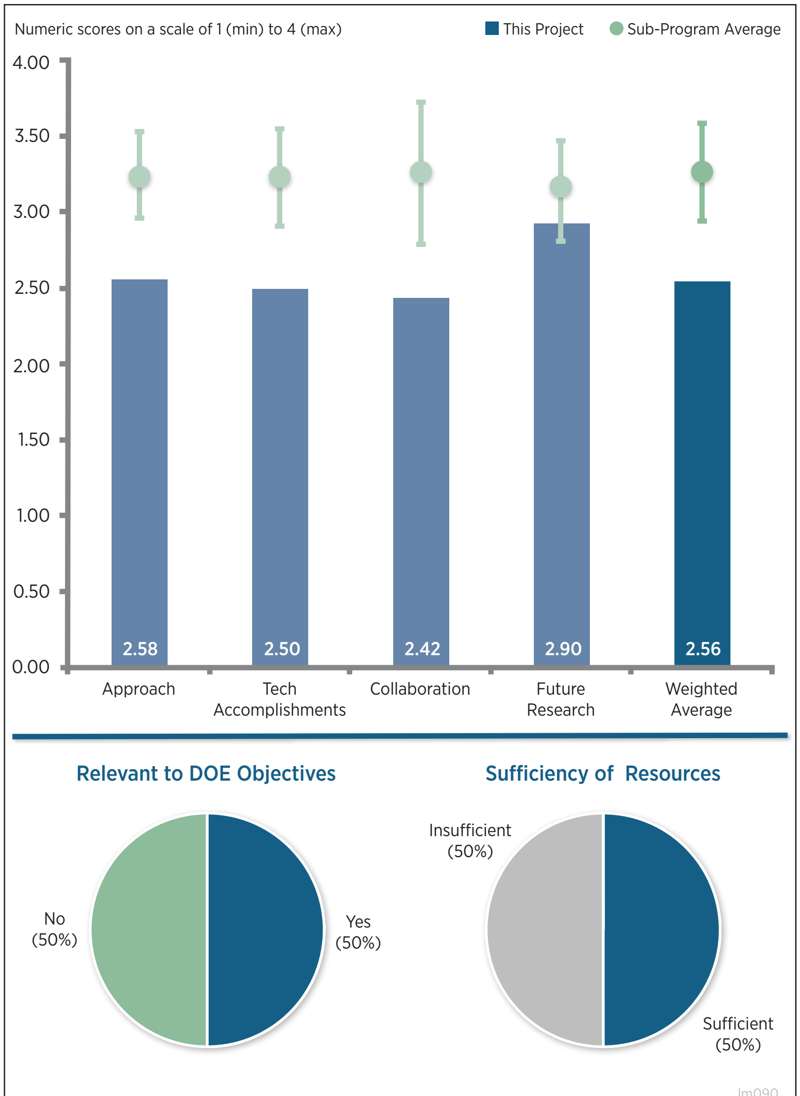

Figure 6-7 – Vehicle Lightweighting: Mass Reduction Spectrum Analysis and Process Cost Modeling: Tony Mascarin (IBIS Associates) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this project clearly outlined the tasks and overall approach to reviewing, identifying, and prioritizing weight reduction path scenarios; collecting data and updating models to develop model scenarios; and refining and analyzing the models in order to present results.

Reviewer 2:

The reviewer did not believe the approach taken will provide meaningful output relative to project objectives. Categorization of the barriers and extracting the cost data provided in the previous literature studies in not optimum for generating useful information.

Reviewer 3:

The reviewer said that the assembly of data from previous vehicle lightweighting initiatives is a useful approach to evaluate their effectiveness and establish a comparative cost basis for each material technology, forming technology, and assembly technology. According to the reviewer, it is unfortunate additional projections of cost based on hybrid composite technologies and the potential opportunities of reducing total part count through part integration has not been considered.

Reviewer 4:

The reviewer did not think that the project really was additive to the question on lightweighting costs. Essentially, the project team took all the lightweight evaluation projects and tried to homologate the outputs and provide a sensible, holistic view on attractiveness. The reviewer did not think it worked.

The reviewer remarked that all of the projects used for this study had some basic flaws in the assumptions, which were increased by trying to map them into a unified report. It seemed like an overly good idea, but the results did not seem realistic, as noted by the animated reviewer response.

Reviewer 5:

The reviewer expressed concern that interpretation of a DOE-funded cost study based on a literature review associated with various studies of different baseline vehicles and assumptions is not a cost modeling effort.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the program did a fine job of assembling and analyzing available program data. The project team drew insightful conclusions and established an important set of metrics to support or justify particular strategies for vehicle lightweighting.

Reviewer 2:

The reviewer detailed that strategies for vehicle lightweighting were characterized into low-, medium-, and high risk. The costs for each strategy were obtained, either from previous work or the team's work, and then presented in the report. The debate regarding cost model accuracy and ease of implementation into vehicles will continue between organizations wishing to position these technologies and those organizations responsible for producing the end product.

Reviewer 3:

The reviewer said that technical accomplishments were not articulated well during the delivery of the presentation. Responses to reviewer questions also did not provide additional clarity on the technical content presented.

Reviewer 4:

The reviewer remarked the team did not seem to have enough technical expertise to sort through the subject matter to make a sound analysis.

Reviewer 5:

The reviewer said that the technical accomplishment is negative in value, and providing misleading information will result in legislation that has a negative impact to industry. The thought that the cost of lightweighting up to 6% is free, and from 6% to 35% can be realized at $1.25/lbs. weight saved, was described as ludicrous by this reviewer.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the level of resources available required a balance of collaborating institutions. The experience of Ibis and the inclusion of Energetics and the national laboratory is admirable.

Reviewer 2:

The reviewer remarked that collaboration appears satisfactory to accomplish this task, although direct interaction with OEMs, tiers, and materials suppliers would be required to more accurately capture cost and risk information.

Reviewer 3:

The reviewer commented that collaboration with the authors of various studies took place.

Reviewer 4:

The reviewer believed that this is one area that more could have been done, and cited as an example collaboration with the Ford/Cosma program on the Multi-Material Lightweight Vehicle (MMLV) program results.

Reviewer 5:
The reviewer said that it would have been good to have included industry composites experts to help with data assessment.

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 this work is complete.

Reviewer 2:
The reviewer remarked that work is completed.

Reviewer 3:
The reviewer emphatically commented that no proposed future research is good.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that cost information is needed to make educated decisions for vehicle production, as well as in making regulatory policy. Cost is only one dimension, of course. The reviewer noted that safety implications, globalization, and consumer demand are but a few other considerations.

Reviewer 2:
The reviewer said that a comprehensive evaluation of lightweighting strategies and the incremental cost associated with their implementation is essential for providing a roadmap for future designs to follow in wringing out the last kilogram of mass possible and the lowest incremental cost. The result will be a reduction of petroleum fuel consumed to meet the nation's transportation needs.

Reviewer 3:
The reviewer said that it was not very obvious how the program is linked broadly to DOE's objectives. The presented categorization of cost/complexity were not articulated well and that is perhaps why this reviewer did not see the relevance.

Reviewer 4:
The reviewer did not believe the output of this report is useful or representative of costs and implementation of technologies.

Reviewer 5:
The reviewer said that the subject is not related to petroleum displacement.

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 resources available were commensurate with the work performed. The reviewer noted that the level of resources were equivalent to approximately three-fourths of a man year's effort and this reflects the level of work accomplished by the program.

Reviewer 2:

The reviewer said that the cost model cannot be conducted by a third party, and that only the manufacturer can conduct such. The reviewer recommended that Ford and Magna be contracted to conduct an incremental cost analysis of the 2013 Fusion, Mach I and Mach II (Body in White [BIW], Chassis & Closures). There is interest by both parties to clarify the incremental cost by subsystem for Mach I.

Reviewer 3:

The reviewer said that this project is complete.

Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components: Adrian Sabau (Oak Ridge National Laboratory) - lm097

Presenter

David Warren, Oak Ridge 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, feasible, and integrated with other efforts.

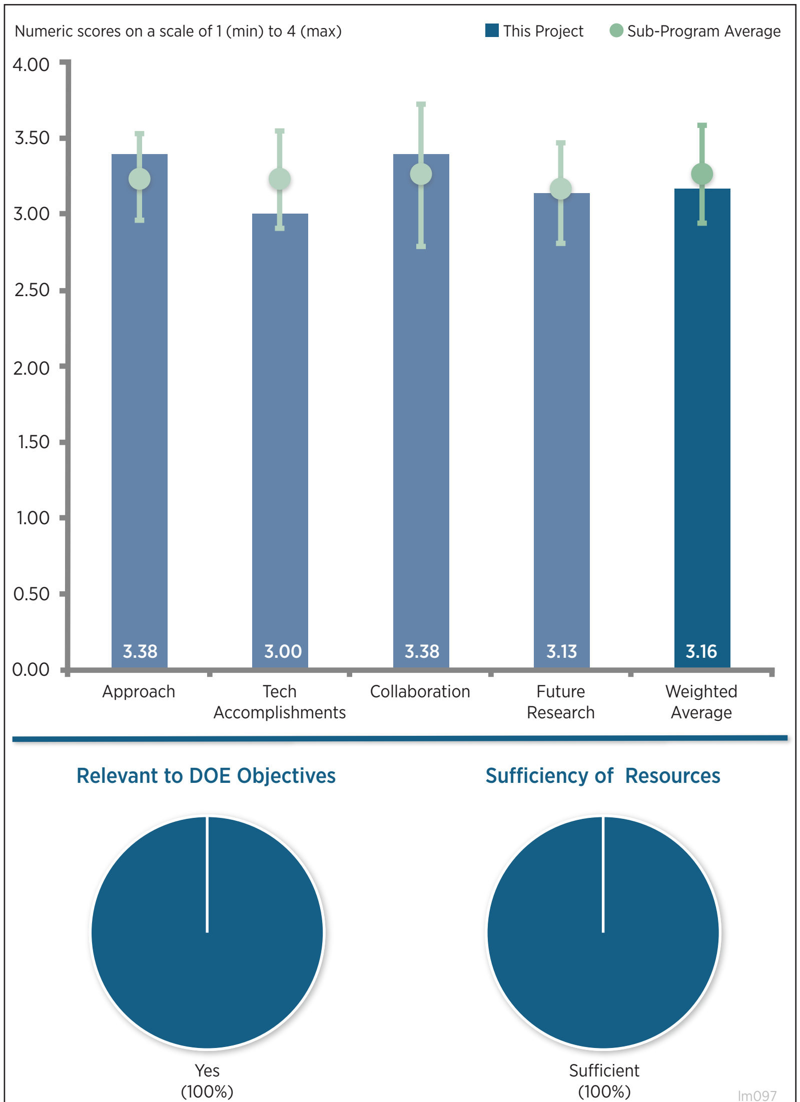

Figure 6-8 – Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components: Adrian Sabau (Oak Ridge National Laboratory) – Lightweight Materials

Reviewer 1:

The reviewer noted a great approach to investigate a laser method to improve adhesive bond robustness between CFCs and sheet Al.

Reviewer 2:

The reviewer said that the laser assisted surface preparation approach used to obtain higher bonding strength is innovative, and could potentially be adopted in high volume automotive manufacturing in the future.

Reviewer 3:

The reviewer pointed out that it would have been great if the current state of the art in the automotive industry would have been described to fully articulate the defects and need for improvements. The BMW I3 program utilizes two different bonding technologies for their BIW construction. The BMW 7 series also utilizes a number of adhesive joining techniques to join Al to CFC, and CFC to steel. The reviewer inquired about the following: how the selected joining techniques differ; what steps in the surface preparation or joining are eliminated as a result of using the suggested joining techniques; and whether it is possible to claim that the best possible adhesive is selected only based on lap-shear evaluations. The reviewer said that the project team should consider alternative joints such as cross-tension or KS2 style specimens to fully evaluate the efficiencies with the proposed work.

Reviewer 4:

The reviewer said that it would be good to have a schematic of the process and suggested either a picture, animation, or video.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project successfully completed DOE's and surface investigations to quantify the improvements and surface conditions.

Reviewer 2:

The reviewer remarked that different joint configurations could have been studied as the samples made for the lap joint are already available. This could have helped to understand the benefits in the modes other than shear studied in this project.

Reviewer 3:

The reviewer suggested incorporating alternative joint geometries. The reviewer also suggested that the team consider adding wedge impact peel, very simple geometry, very simple test setup, and data analysis to better understand the benefit of suggested joining on dynamic impact problems.

Reviewer 4:

The reviewer said that although the presented results are satisfactory, it would be good to make the following change so as to look at the problem more accurately. The reviewer said that the bondline thickness measurement should be substituted by contact area which is more in the laser-rastered sample than non-laser sample and then re-analyze the results to see if the same conclusions are reached. The reviewer said that technically, an electrically insulating layer is not provided because the carbon within CFRP is exposed using laser etching.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted wonderful cooperation to get the samples made, conditioned, and tested.

Reviewer 2:

The reviewer said none.

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 solid proposals for scale-up to volume production.

Reviewer 2:

The reviewer said that the team has a good plan in place to scale the developed process to a production intended process. Also, the tests planned for assessing the joint strength are necessary to understand the impact of laser assisted joining process in other configurations.

Reviewer 3:

The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the technology developed in this project directly helps the future multi-material material designs adopted by the automotive industry for lightweighting.

Reviewer 2:

The reviewer remarked that joining will remain the number one barrier in usage of all lightweight materials.

Reviewer 3:
The reviewer said that this is a very critical problem to be solved in the current context of multi-material implementation within the automotive sector.

Reviewer 4:
The reviewer pointed out that bonding CFC to Al is a critical joining technology for lightweight vehicles of the future.

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

No comments were received in response to this question.

Brazing Dissimilar Metals with a Novel Composite Foil: Tim Weihs (Johns Hopkins University) - lm098

Presenter

Tim Weihs, Johns Hopkins University

Reviewer Sample Size

A total of five reviewers evaluated this project.

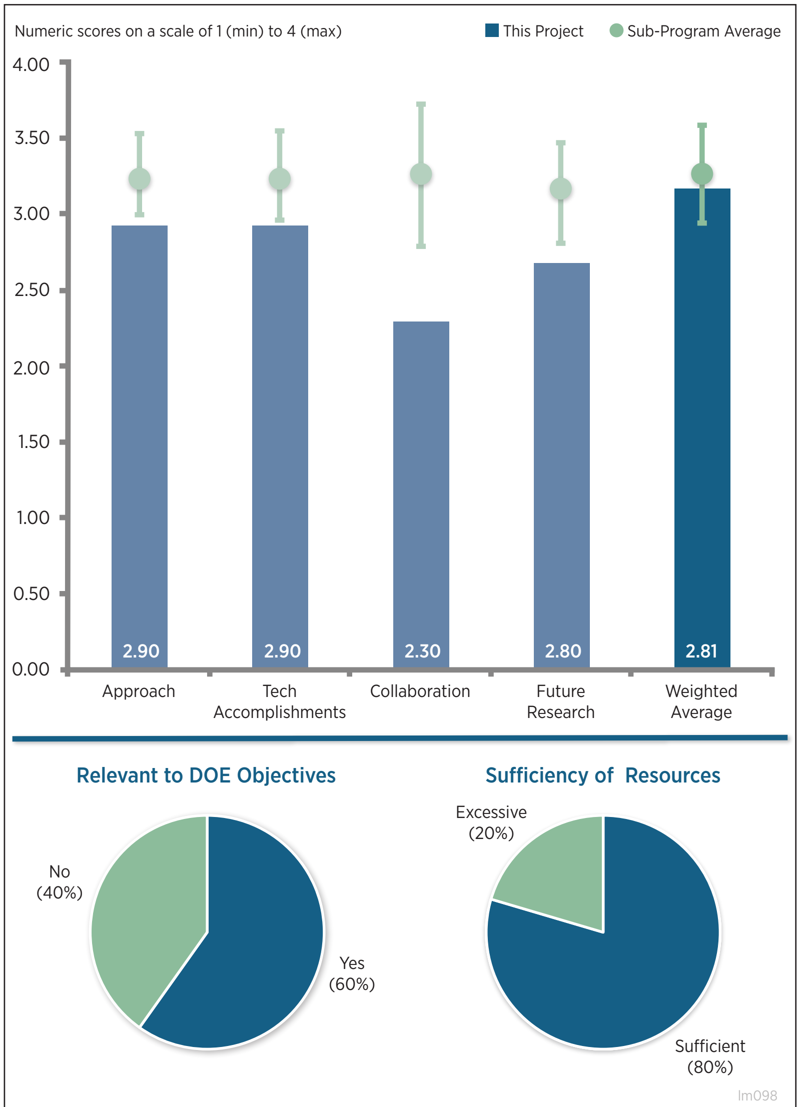

Figure 6-9 – Brazing Dissimilar Metals with a Novel Composite Foil: Tim Weihs (Johns Hopkins University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed a good approach at solving issues with reactive metal oxides. Good analysis of processes between diluent and reactive zones. The approach evaluates four metal oxide compounds used in redox foils fabricated by consolidating, swaging, and rolling micron sized powders and the effects of quenching and dilution at the microstructure level. The reviewer commented that the experimental approach resulted in the selection of Al: copper (I) oxide: copper ($Al:Cu_2O:Cu$) as the best candidate to use in the next level of experimentation.

Reviewer 2:

The reviewer said that this is a worthwhile project because the future vehicle will require a range of different materials to achieve greenhouse gas (GHG) and crashworthiness targets at a realistic cost. Joining these materials is therefore a core enabling technology in this reviewer's view. The approach being taken by this group appears to be realistic and systematic as the project team endeavors to find just the right formulation for its brazing foils. It appeared to this reviewer that the project team is making progress and has made progress on addressing the comments of earlier reviews. Acknowledging that it is beyond the scope of the present work, the reviewer wondered how repairs might ever be accomplished on an actual vehicle in, for example, a commercial auto body repair shop. The reviewer emphasized that this remark is not intended in any way as a criticism of the present project.

Reviewer 3:

The reviewer commented that this is a wild research/stretch approach to see the applicability of using foils for joining dissimilar metals. However, the approach lacks robustness for other performance issues such as corrosion, paint ability, surface finish, etc. The reviewer said that this is okay for such an early research project, and asked if cost or joint processing parameters were part of the project scope.

Reviewer 4:
The reviewer said that the approach is without potential application to transportation vehicles, and commented that it should be funded by Advanced Research Projects Agency – Energy (ARPA-E) or the National Institute of Standards and Technology (NIST).

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that it appears that the group has identified key concerns in the work and appears to have a plan for addressing each one.

Reviewer 2:
The reviewer remarked that the project is progressing on track against its plan. The developments and investigations in the diluent and reactive components appear to be going on track, but the chemistry is still apparently elusive, and the lack of cost discussion in this project is disappointing. The reviewer said that the chemistry evaluations appear to guide you to the best solutions, and the additional costs need to be included in the investigations. The reviewer asked how the strengths can be increased.

Reviewer 3:
The reviewer said that the presenter did not address DOE goals; however, the technical accomplishments and progress have addressed the major technical issues for the materials being considered. The research is technically sound, but the relationship to DOE goals is weak. The reviewer remarked that experimental results have shown ways of increasing the bond strength, minimizing excessive melting, and decreasing porosity from excessive gas generation during bond formation. Investigations into ball milling resulted in increased homogeneity and reduction of heat diffusion distances, which are very good results. The reviewer said that the heat diffusion modeling efforts are beneficial to improving the technology. All of these contribute to the degree of progress to date as measured against performance indicators found in the project milestones.

Reviewer 4:
The reviewer remarked that 10 megapascals (MPa) lap shear strength is not applicable to vehicle technologies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed only satisfactory cooperation, and that the roles are not as clearly defined as the reviewer wanted to see.

Reviewer 2:
The reviewer commented that the presenter only listed two sources for collaboration and coordination; one is a fellow researcher and post-doctoral employee, and the second is a supplier of material to be tested. There is no collaboration with potential sources in the supply chain or with manufacturers who would be interested in the technology, if the research is successful. The reviewer observed minimal collaboration and no OEMs.

Reviewer 3:
It appeared to this reviewer that the major work is being done at Johns Hopkins University with some involvement from a former student who is based in Germany. The only industrial sponsor identified is Severstal, which supplies the materials. The reviewer would have appreciated knowing that an actual body structure manufacturer is interested in this work because without an actual application or potential target customer, it is challenging to see how viable an investment this represents for the DOE program.

Reviewer 4:
The reviewer said that collaboration with a former post doc is not collaboration.

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 plans are okay for this level of research project as measured against the stated project proposals.

Reviewer 2:

The reviewer remarked that overall, the future research proposed seems to address potential problems with the technology.

Reviewer 3:

The reviewer commented that the plan lacks direction, and that there is no plan to address corrosion issues.

Reviewer 4:

The reviewer indicated that the proposed future work only supports half of the remaining challenges and barriers and quoted "Mass ejection and porosity in bonds" and "Molten braze from Redox reaction wets poorly." The reviewer pointed out that no future work is proposed to address issues with brazing. Instead, two other efforts are proposed: "Create statistically signification datasets for shear strengths of bonds and determine the modes of failure in the joint;" and "Analyze the braze and base metal interface for any changes in mechanical properties of base metal due to heating from the reaction of the Redox Foil." The reviewer said that nothing is mentioned regarding the four months for each effort that addresses bond strength, failure modes, corrosion behavior, and component degradation shown in the milestone chart on Slide four.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that all new ideas for joining dissimilar materials need to be explored to enable lightweight vehicle construction.

Reviewer 2:

The reviewer said it potentially supports DOE goals, but is essential to identify a potential target customer soon to ensure that there will be a return on the investment.

Reviewer 3:

The reviewer said that although the objective stated that the effort is to develop and characterize novel reactive foils for use in bonding dissimilar materials, there is nothing in the written or oral presentation that explains how this research will be used in lightweighting applications that will directly support the overall DOE objectives to make lightweight vehicles that will displace or reduce the use of petroleum. The relevance discussed applies to determining the best chemistry and increasing quantity of braze in the foils from 65% to 74%, which is relevant to research goals, not DOE goals.

Reviewer 4:

The reviewer remarked that there is no tangible means as to how reduction oxidation can reduce vehicle mass and associated fuel reduction.

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 this is a four-year research project to improve a bonding technique for $640,000 ($160,000 per year average). All previous milestones have been met with the funding provided and all future milestones are reported as on track for the remaining amount of funds. The reviewer remarked that resources are sufficient to achieve the stated milestones.

Reviewer 2:
The reviewer said that resources look okay.

Reviewer 3:
The reviewer strongly recommended that this project be cancelled.

High-Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks: Yuri Hovanski (Pacific Northwest National Laboratory) - lm099

Presenter

Yuri Hovanski, 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, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this is one of the best funded projects in the current DOE portfolio, well scoped out and executed.

Reviewer 2:

The reviewer observed an outstanding approach to developing and progressing the state-of-the-art for friction-stir welding (FSW) of Al tailor blanks.

Reviewer 3:

The reviewer noted a vertical supply chain with a tangible product application, which provides mass reduction benefit.

Reviewer 4:

The reviewer said that this project appears to be highly focused, well organized, and is on-track to achieve its goals. A key thing is that the project team has engaged the entire supply chain, right through to an eventual technology deployment client (General Motors).

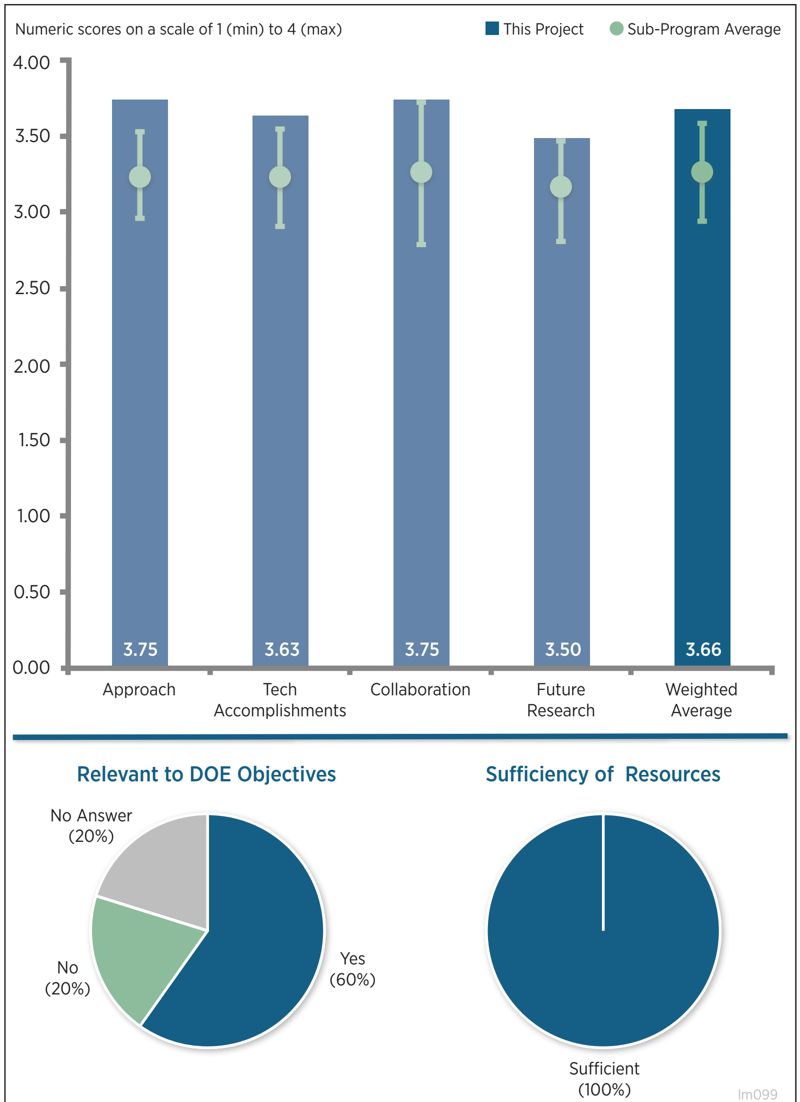

Figure 6-10 – High-Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks: Yuri Hovanski (Pacific Northwest National Laboratory) – Lightweight Materials

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project is reportedly ahead of schedule and somewhat underspent, despite the fact that the team is considering a very wide array of variables and all of the necessary potential negative factors in the process. The learnings and progress toward a viable process are all impressive.

Reviewer 2:

The reviewer observed good results to date.

Reviewer 3:
The reviewer said that work has focused on the barriers and has solid experimental foundations.

Reviewer 4:
The reviewer commented that results look excellent. The reviewer would like to see actual stamping trials in the last phase to show performance of the FSW blanks under truly high strain rate forming, and taking it beyond limiting dome height (LDH) testing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed great teamwork.

Reviewer 2:
The reviewer said that it would appear that the team is properly constituted, working effectively together, and sharing results in a positive fashion.

Reviewer 3:
The reviewer stressed that collaboration is the key.

Reviewer 4:
The reviewer described a perfect mix of collaborators that include an OEM, national laboratory, and academia.

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 plan to integrate FSW of 7xxx Al is a great stretch target.

Reviewer 2:
The reviewer said that the project looks like a great plan for the next phase of work—comprehensive, realistic, and goal focused.

Reviewer 3:
The reviewer said that the project has solid proposed work to address remaining tasks, and there are good ideas for future commercialization through partners.

Reviewer 4:
The reviewer suggested trying to include the high-strain rate testing via conventional stamping.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer asserted that this project is definitely and firmly aligned with the program goals. The reviewer also pointed out that the project team seems to be very conscious of final product cost, which is also a crucial aspect of success for a new technology.

Reviewer 2:
The reviewer said that tailor-welded blanks (TWB) are a proven weight-saving opportunity, and that we need this technology for Al sheets.

Reviewer 3:
The reviewer remarked that this project is definitely focused on next-generation joining and vehicle lightweighting.

Reviewer 4:
The reviewer declared that mass is not saved, and that the process saves cost by improving scrap utilization.

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 yes, this experienced team appears to be adequately resourced.

Reviewer 2:
The reviewer said that the project is appropriately funded.

Upset Protrusion Joining Techniques For Joining Dissimilar Metals: Steve Logan (Fiat Chrysler Automobiles US LLC) - lm100

Presenter

Steve Logan, Fiat Chrysler Automobiles USA LLC

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, feasible, and integrated with other efforts.

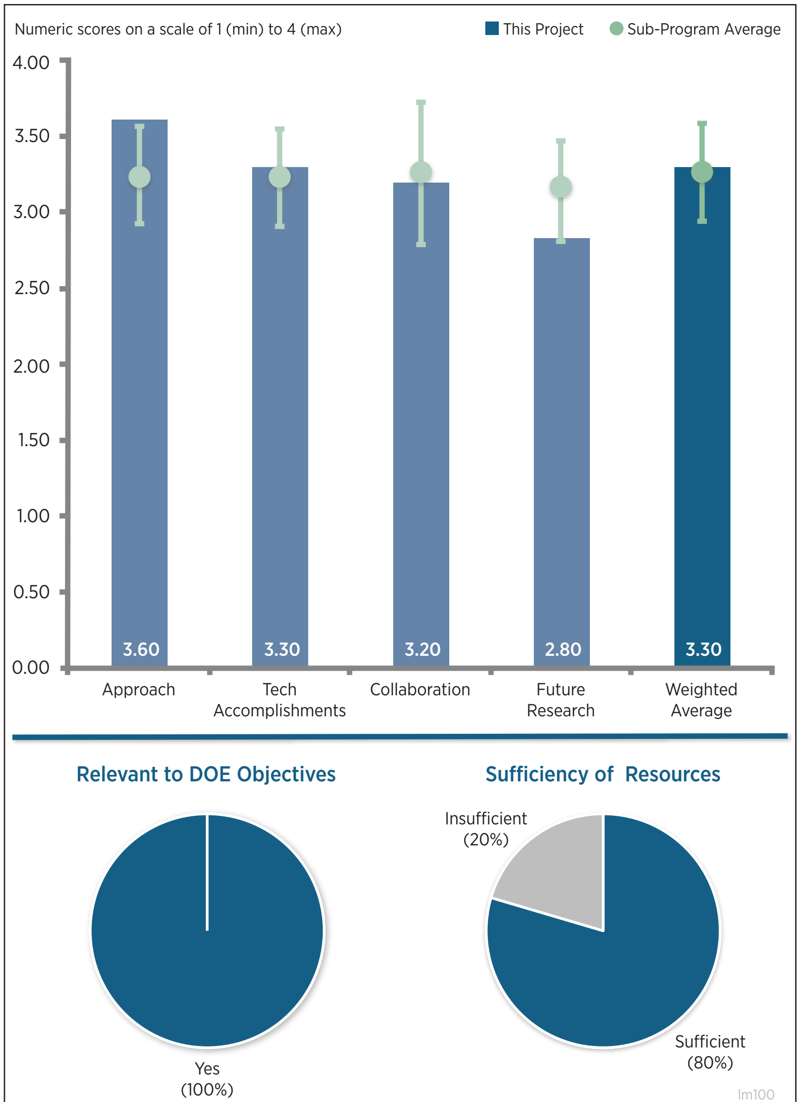

Figure 6-11 – Upset Protrusion Joining Techniques For Joining Dissimilar Metals: Steve Logan (Fiat Chrysler Automobiles US LLC) – Lightweight Materials

Reviewer 1:

The reviewer observed a great test matrix.

Reviewer 2:

The reviewer noted an outstanding approach and testing plan with great statistical analysis, and added that this will supply a solid data set to the industry.

Reviewer 3:

The reviewer said that this is an excellent project, well scoped-out, and related to the needs for more mixed materials joining solutions.

Reviewer 4:

The reviewer said that the program covers the important aspects of applying this technology to production.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked great progress and interesting results, and the reviewer hoped the last phase might include a run at rate study including repeatability studies, mechanical properties, and a roughed-out business case.

Reviewer 2:

The reviewer noted excellent accomplishments and timely data, and that the accomplishments are keeping the project on track.

Reviewer 3:
The reviewer said that the project seems to have developed the information needed for a business case decision to be made on applying this technology to production, and a sound base of information on which to develop a similar case for other material systems.

Reviewer 4:
The reviewer said that results associated with the test plan revealed difficult challenges and the limitations of the process.

Reviewer 5:
The reviewer said that the project is very ambitious and there is too much to do to satisfy DOE requirements. As a consequence, the number of tests per material combination is too small and the reviewer questioned the reliability aspect of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed a great mix of OEM, national laboratory, and academic involvement.

Reviewer 2:
The reviewer described utilization of outside resources to conduct casting and corrosion testing as good.

Reviewer 3:
The reviewer observed a good team of collaborators with clear roles and responsibilities.

Reviewer 4:
The reviewer said that collaboration was good, but too restricted.

Reviewer 5:
The reviewer said that the interconnection of efforts was not as readily apparent as with other projects.

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 that the proposed future work will address what questions and tasks remain in this project.

Reviewer 2:
The reviewer remarked that the project is close to completion and does not respond to the question of the process reliability. The principal investigator (PI) commented that Fiat Chrysler Automobiles is doing other work on the subject.

Reviewer 3:
Looking for more component level assemblies with post corrosion testing of mechanical joint strength was reported by this reviewer.

Reviewer 4:
The reviewer did not observe many insights on how to build on this work, and highlighted that only corrosion testing is being finished.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer emphasized that dissimilar material joining is basically the issue for multi-material lightweight auto bodies, and this technology is a valuable addition to the slate of possibilities.

Reviewer 2:

The reviewer said that joining of dissimilar materials is challenging, and that the project illustrated the proper project methodology and demonstration of plan execution.

Reviewer 3:

The reviewer commented that joining to Mg is one of the key enablers for lightweight mixed material structures.

Reviewer 4:

The reviewer said that the project fulfills a need for more innovative and effective mix metal joining technology.

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 an appropriate amount of funding for the project.

Reviewer 2:

The reviewer remarked about the fact that the number of tests per material combination is too small.

Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles: Xuming Su (Ford Motor Company) - lm101

Presenter
Xuming Su, Ford Motor Company

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

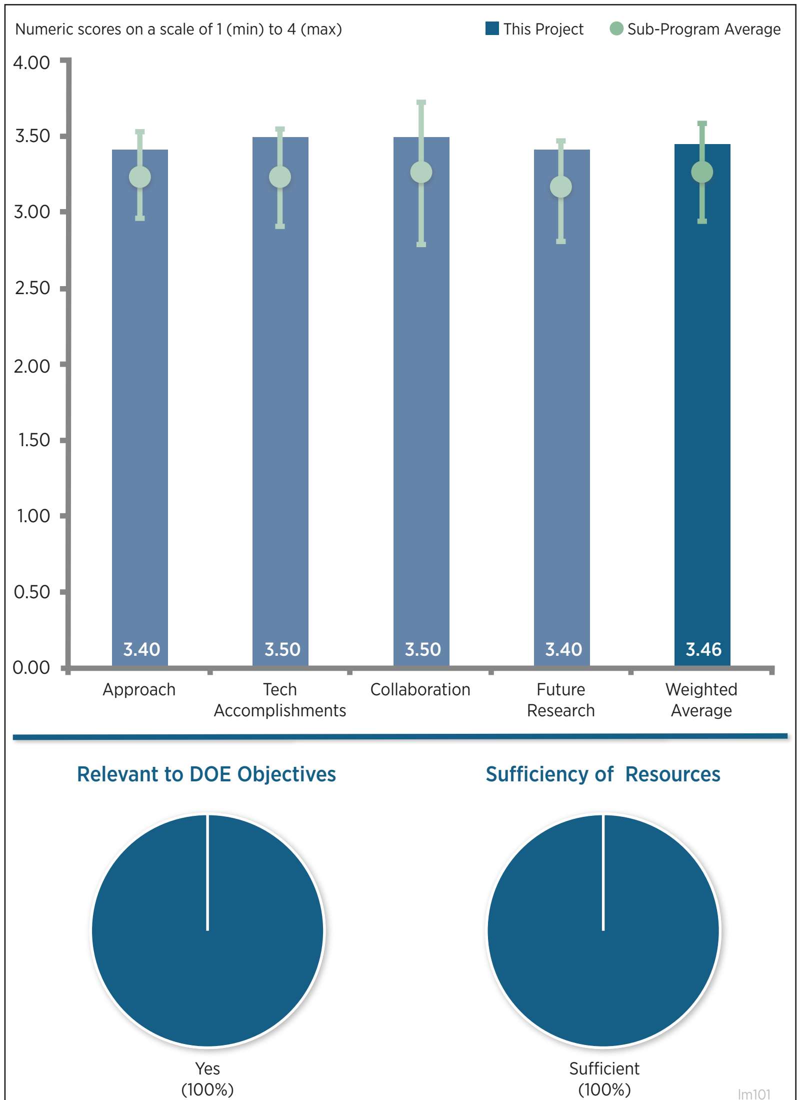

Figure 6-12 – Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles: Xuming Su (Ford Motor Company) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:
The reviewer remarked that the ICME approach developed in this project for predicting the manufacturing and structural performance will exponentially speed up the lightweighting efforts of automobiles using CFCs. The technology being developed in this project has the potential to meet DOE targets; namely, 25% weight reduction and cost increase less than $4.27/lbs. compared to current steel assemblies.

Reviewer 2:
The reviewer said that the plan seems quite realistic, but additional detail on how the technology will eventually be deployed would be welcome.

Reviewer 3:
The reviewer said that the approach taken to developing the ICME models, modules, and processes is very well conceived. There is little doubt that the project will lead to capabilities that accomplish the project's technical goals. The reviewer said that the only element that might improve the work is consideration of alternative continuous fiber material forms. The reviewer said that using woven carbon reinforcements makes the overall cost targets (i.e., less than $4.27/lbs. weight saved) close to unattainable.

Reviewer 4:
The reviewer asked what the impact is on data with large-tow CF, and what the impact is of using same-tow CF but different sizes of CF. The reviewer suggested adding thermoplastic (polyamide [PA]/polyphthalamide [PPA] or high performance) non-woven material to evaluation materials as a lower cost alternative to thermoset.

Reviewer 5:
The reviewer asked how the team intends to do the cost analysis to meet cost limitations. Meeting cost targets is a

big challenge and the team should consider cost targets well in advance of the project by looking at different fiber forms and tow sizes rather than dwelling too deep into existing fiber forms.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer said that the team appears to be making good progress against the objectives.

Reviewer 2:
The reviewer reported excellent progress in the last year: selecting the material system; representative volume element (RVE) unidirectional (UD) development; performing simulations; molding simulation of compression molding; and process integration, including Moldflow, LS-DYNA, NASTRAN, and nCode. The reviewer asked if molecular dynamic analysis (MDA) tools are integrated with the developed ICME tools or whether they work alone. The reviewer also asked what the plans are to link uncertainty quantification models with the deterministic ICME models.

Reviewer 3:
The reviewer said that the work on MDA is particularly impressive with a strong correlation of predicted mechanical and thermal properties. The work completed on fatigue analysis is also very well done. The balance of the work accomplished is commensurate with the technical approach and expectations of the program. The reviewer said that the project needs to address cost factors. The progress on technical modeling is outstanding. However, this reviewer opined that it will not see the light of day without similar attention paid to economics of the processes studied and development of integrated cost models that provide a similar level of fidelity regarding the cost of structures fabricated.

Reviewer 4:
The reviewer commented that deformation of the fiber mat during processing should be considered while deriving the material properties to be used in finite element analysis (FEA).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted excellent collaboration among the project team members.

Reviewer 2:
The reviewer commented that the inclusion of strong academic institutions (i.e., Northwestern and Maryland) to support development of analytical tools and material characterization, a leading OEM and material supplier, along with important commercial software developers, makes this a winning team.

Reviewer 3:
The reviewer said that collaboration looks okay.

Reviewer 4:
The reviewer suggested investigating thermoplastic options.

Reviewer 5:
The reviewer said none.

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 proposed future research addresses some of the major challenging facing the industry in large-scale implementation of composite materials in automobiles. Based on the strong performance last year, the reviewer expects the project to accomplish all the remaining challenges.

Reviewer 2:
The reviewer said that the forward plan appears to be well focused and the project is likely to continue resulting in good progress.

Reviewer 3:
The reviewer said that the proposed work for the coming period is well tailored to meet the technical objectives to demonstrate application of a strong ICME environment for automotive component design for CFRP. The reviewer said that the overall program will be strengthened if more consideration is placed on the economic modeling. Providing a strong cost model as part of the integrated design environment is an essential part of ensuring cost targets that result in viable commercial components are achieved.

Reviewer 4:
The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that the ICME technology being developed in this project has the potential to achieve the overall DOE objective of 25% lighter assemblies in automobiles using CFCs. This will directly improve the fuel economy and reduce emissions. The reviewer also pointed out that using this technology, significant reduction in manufacturing costs of components with improved quality can be obtained and while eliminating costly trial and error.

Reviewer 2:
The reviewer asserted that the project does appear to be aligned with DOE's program goals.

Reviewer 3:
The reviewer said that this program will ensure that future designers have the tools needed and the methodologies established that will result in reliable automotive composite designs that exploit the use of high specific proprietary materials in transportation systems reducing wait and thereby reducing fuel consumption. The reviewer said that it remains important to consider the trade of incremental cost for each pound of weight saved. More work should be done to provide an economic basis for that trade-off.

Reviewer 4:
The reviewer said the project is very much needed in the current context of extensive use of composites within transportation sector because ICME development will lead to not only rapid advancements in materials but also virtual investigations prior to fabrication and testing. Thereby, millions of dollars in cost would be saved.

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 look okay.

Reviewer 2:
Given the scope of work identified, the reviewer found that the goals stated and approaches proposed are commensurate with the budget established for this work. The resources available should be sufficient to support the vast amount of data generated and analysis tools developed along with the design work required to complete this effort.

Predictive Models for Integrated Manufacturing and Structural Performance of Carbon Fiber Composites for Automotive Applications: Venkat Aitharaju (General Motors) - lm102

Presenter

Venkat Aitharaju, General Motors

Reviewer Sample Size

A total of five reviewers evaluated this project.

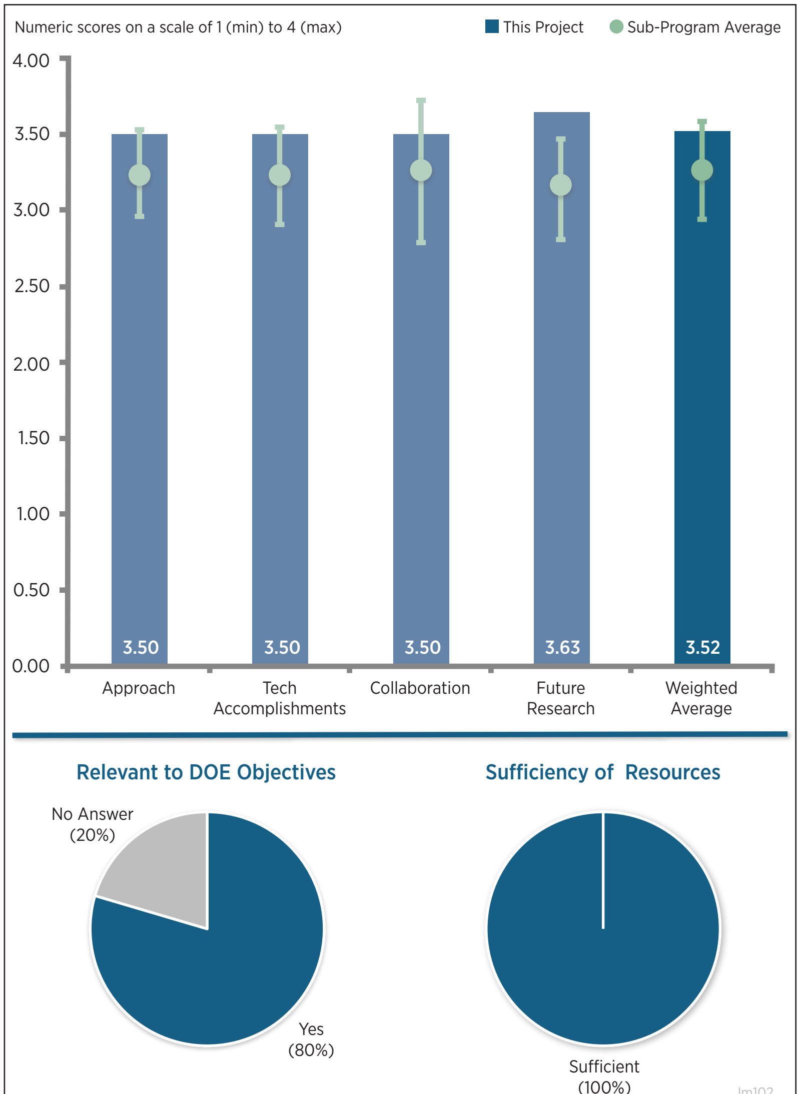

Figure 6-13 – Predictive Models for Integrated Manufacturing and Structural Performance of Carbon Fiber Composites for Automotive Applications: Venkat Aitharaju (General Motors) – Lightweight Materials)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the performance of CFRP is strongly dependent on manufacturing processes and varies from location to location. The project takes an integrated analysis approach, considering manufacturing and local variability, and is exactly needed for the problem.

Reviewer 2:

The reviewer said that the approach is a bit vague and the overall scope is overly optimistic. Characterizing material models, and evaluating process simulation and structural performance for a full suite of thermosets, thermoplastics, chopped-, uni-, and woven composites, were described as lofty goals by this reviewer. The reviewer added that the project seems too ambitious to be completed by 2019, particularly with one goal being to account for uncertainty across scales. The reviewer commented that the process flow of tool development needs to be refined to more clearly show the process steps.

Reviewer 3:

The reviewer suggested that the team look into other distributions (than uniform well in-advance of the work plan), which might result in different process development flow and uncertainty modeling approaches.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that great progress has been made, and a lot of data has been collected for the short period.

Reviewer 2:

The reviewer observed good progress so far.

Reviewer 3:

The reviewer noted that the project was initiated in May 2015 and it is still early in the project. The reviewer listed the following: analysis method was developed; manufacturing methods were identified; material systems were selected and tested; material characterization for tension, three-point bending, and crush was done; and crush testing was completed. This reviewer would like to see more specific results presented in future reviews.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that major relevant elements of a successful project have been assembled.

Reviewer 2:

The reviewer said that a good balance of collaborators exist, with one OEM, a Tier 2 supplier, modeling companies, and a university, but suggested that the project should consider material suppliers. This reviewer is interested in the pre-competitive research that will be generated in order to benefit the industry.

Reviewer 3:

The reviewer would like to see the project include chopped CF thermoplastic prepreg or three-dimensional (3D) preform materials. This is a lower cost approach than resin transfer molding (RTM)/thermoset. In overview, the reviewer would like to see more thermoplastic in the project based on recycling, cycle time, and more simplistic chemistry than thermosets.

Reviewer 4:

The reviewer said there is more to do for the common good than what is presented.

Reviewer 5:

The reviewer remarked none.

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 proposed future work seems appropriate. Project plans for 2016 include completing data collection for manufacturing and structural performance simulation tools, completing the stochastic manufacturing simulation tool, and completing the stochastic performance simulation tool for three material systems.

Reviewer 2:

The reviewer said that the proposed future works emphasizes uncertainty characterization. As predictive tools, modeling of uncertainty transfer from one scale to another would be important and interesting.

Reviewer 3:

The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that the work outlined in this project supports the overall DOE objectives of helping to develop and support lightweight automotive applications to reduce fuel and GHG emissions.

Reviewer 2:

The reviewer said that predictive modeling of composites is a challenging issue to solve in the current context of composites modeling efforts. If successful, the project will help to reduce the overall system costs by advance probability estimates of failures.

Reviewer 3:

The reviewer said yes, but RTM with thermoset chemistry has not been demonstrated as a cost-effective high volume process. The European OEMs who typically lead this type of advanced technology development seemed to have dropped this as a prime path. The reviewer suggested including a high-temperature thermoplastic, such as PPA.

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 resource funding for this project seems appropriate for the amount of work and results expected. This reviewer would like to better understand the precompetitive work that will benefit the industry.

Reviewer 2:

A perfect set of resources was observed by this reviewer.

E. Coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors: Randy Lewis (Utah State University) - lm103

Presenter

Randy Lewis, Utah State University

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

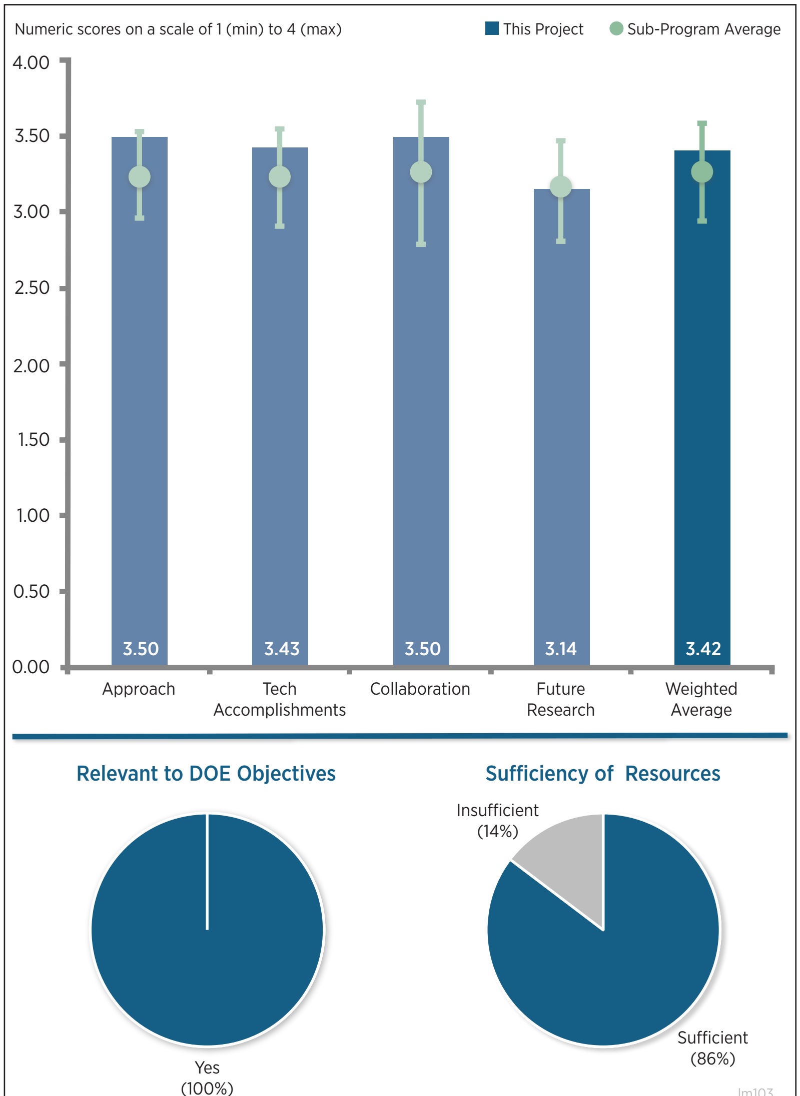

Figure 6-14 – E. Coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors: Randy Lewis (Utah State University) – Lightweight Materials

Reviewer 1:

The reviewer noted an outstanding approach to solving the challenges of lightweight composites in the automotive industry using spider silk as CF precursors. Simplified, the approach is as follows: first, produce fibers; second, convert to CF; and third, complete economic analysis.

Reviewer 2:

The reviewer pointed out that the bio-material is green and would be abundant.

Reviewer 3:

The reviewer observed a good plan to evaluate non-traditional material source.

Reviewer 4:

The reviewer said that the problem being worked on (producing low-cost CF) is potentially a very important component of future lightweight vehicle technology. The overall approach is intriguing and appears to be successful at producing actual CF, but whether this can be done at a commercially feasible cost in commercially relevant quantities remains to be seen. The reviewer further explained that key problems that have come up appear to have been addressed in the project plan. Subsequently, the overall approach is, in this reviewer's view, very good. The reviewer looked forward to further results from this project team as the team continues with its work on this very interesting project.

Reviewer 5:

Referencing the presentation (slide deck), the approach could be better defined for the reviewer. The reviewer asked that notes be added in the slide deck next year. The project approach is a bit confusing without the presenter. The reviewer did understand the project approach much better after the presentation. From a research perspective, the scientific approach is interesting and innovative. The reviewer looked forward to seeing the project results next year. The reviewer did not believe the team has enough time in the project to allow for Oak Ridge National Laboratory (ORNL) to optimize the fiber properties to show the true potential.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer observed good progress.

Reviewer 2:
The reviewer said that accomplishments look good, lots of issues remain, and to keep going.

Reviewer 3:
The reviewer said that the technical accomplishments are good and can help meet DOE goals for producing lightweight vehicles; however, many challenges are still outstanding, including producing fibers with sufficient strength and a reasonable cost. The learnings from this project may lead to continued research in this area.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that this is a complex initiative, and it appears that the right people are involved and working together effectively. The blend of engineering, biotechnology, entomology (insects), and manufacturing is really rather unique.

Reviewer 2:
The reviewer said that the project team seems to have the right partners and are working well together.

Reviewer 3:
The reviewer detailed that Utah State University is working with two other universities (i.e., University of California and Arizona State University) and two national laboratories. The reviewer said it was mentioned in the Question and Answer Session that collaboration was occurring with an automotive composites supplier and an aircraft composites supplier. This is good science and may lead to more research. Thus, sharing the knowledge via publication could be important.

Reviewer 4:
The reviewer noted limited collaboration due to nature of project, and that collaboration with ORNL was efficient.

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 looks good but it is likely too early to say for sure. Overall, the presentation was realistic but optimistic, and this reviewer is in the same mindset with respect to this project. In this reviewer's view, it is worth a try.

Reviewer 2:
The reviewer said good, and elaborated that the proposed future work describes several activities to improve the fiber properties, including optimizing the oxidation process, using crosslinking agents, improving processing conditions, etc. The reviewer's confidence is low that goals and objectives will be met before the end of the defined program, and future research in this area may be beneficial.

Reviewer 3:
The reviewer would like to see go/no go decisions incorporated into the plan, and an additional emphasis on cost

comparison and impacts on carbonization process. The reviewer also noted demonstration of benefits at small scale component.

Reviewer 4:

The reviewer would like to see efforts in commercializing the research before completion of the project, and would like to see a CFC made with fibers from spider silk.

Reviewer 5:

The reviewer does not believe the team has allocated enough time to do the proper oxidation, test cross linking, and test different spider silk proteins. The reviewer hoped that the team obtains some promising results and can continue with another grant and more time to develop.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that it certainly does meet DOE's objectives, if this all works.

Reviewer 2:

The reviewer asserted that this project supports the overall DOE objective of developing lightweight automotive applications. As an incubator project, it is still early in the development phase, yet the approach seems solid. There is some good work established, but this reviewer indicated that there is a long way to go to meet the objectives.

Reviewer 3:

The reviewer responded yes, but only if the research shows promise to meet cost and performance of current CF. The minimum properties target physical properties need to be as good as Toray T700.

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 resources will not be sufficient to meet the stated goals and objectives outlined in the documentation. The project is three-quarters of the way completed with a target end date of October 2016, yet the program has a long way to go. The reviewer said that the science is good, and more work needs to be done.

Reviewer 2:

The reviewer commented that the team appears to be well-resourced.

Solid-State Body-in-White Spot Joining of Al to AHSS at Prototype Scale: Zhili Feng (Oak Ridge National Laboratory) - lm104

Presenter

Zhili Feng, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

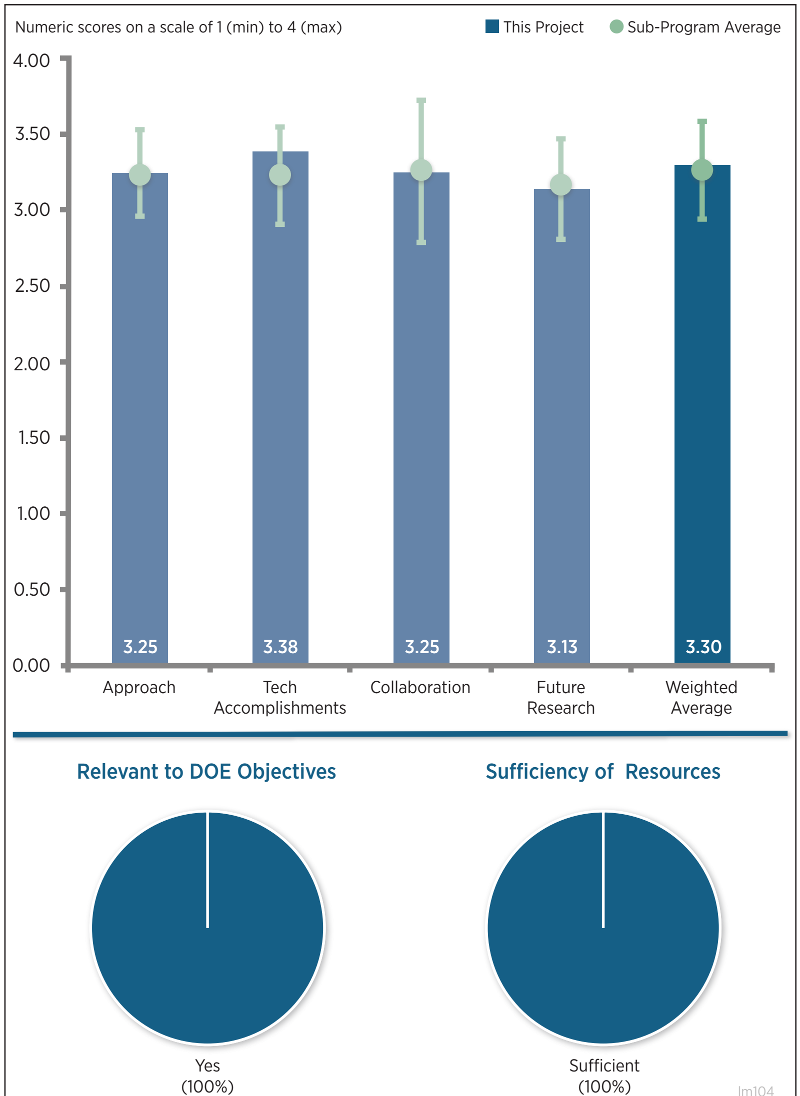

Figure 6-15 – Solid-State Body-in-White Spot Joining of Al to AHSS at Prototype Scale: Zhili Feng (Oak Ridge National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the project appears to be well-organized and sensibly designed to work toward actual on-vehicle deployment.

Reviewer 2:

The reviewer said that the chemistry of adhesive used should be presented. An understanding of the temperature at the joint interface should also be presented so as to investigate adhesive degradability. The reviewer remarked that any aging study should be planned because if there are issues at the adhesive interphase then they will get magnified due to aging.

Reviewer 3:

The reviewer said that the details on the modeling effort to predict microstructures is not well described in the presentation. The reviewer would like to know how this effort will integrate into the process. This reviewer also inquired about the following: the processing variables from either process that are being correlated to good resulting microstructures; how the modeling is being informed by experiment; and the existence of any generic predictive capability, or the need to be completely re-trained on each new material system pair.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the mechanical testing seems to be moving along well, but the modeling was not presented beyond thermal distortion FEA predictions. The assertion that the friction stir spot welding process squeezes out the adhesive at the point of welding was made with little backup evidence. The reviewer asked whether the degraded adhesive changes the local chemistry at the weld, affecting either corrosion performance or strength.

Reviewer 2:

The reviewer said that progress toward project goals appears to be on track, although additional information on the role and type of the adhesive would be welcome as this is a unique aspect of this project versus other dissimilar materials joining projects.

Reviewer 3:

The reviewer referenced prior comments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that there seems to be a nice tie in between the joining experts and the industrial end users. The reviewer said that the modelers and how they tie in and interact with the team was not completely fleshed out in the presentation. The reviewer inquired about who owns the friction bit joining IP.

Reviewer 2:

The reviewer said that collaboration among the various participants in the project appears to be good, although relatively little was said about the specific contributions and roles of each partner.

Reviewer 3:

The reviewer said none.

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 group appears to have identified the major concerns and issues going forward, but that little was said about the details. Thus, a real evaluation of the forward plan is difficult.

Reviewer 2:

The reviewer referenced prior comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that dissimilar joining technologies are critical to the implementation of a multi-material lightweight vehicle body, and understanding these processes will be well worth the effort

Reviewer 2:

The reviewer declared that this one is well aligned with the goals of the DOE program, as is the case with all dissimilar materials joining projects.

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 appear to be okay.

Friction Stir Scribe Joining of Al to Steel: Yuri Hovanski (Pacific Northwest National Laboratory) - lm105

Presenter

Yuri Hovanski, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

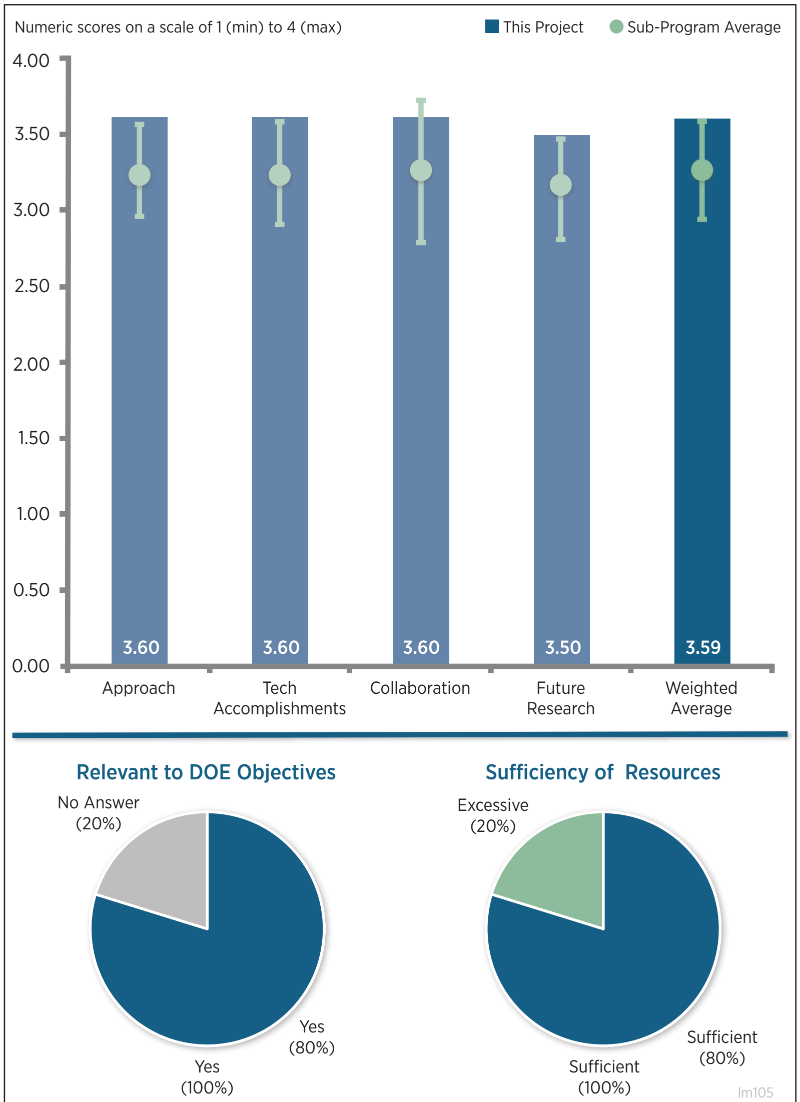

Figure 6-16 – Friction Stir Scribe Joining of Al to Steel: Yuri Hovanski (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said as the need for more mixed metal joining techniques arise for multi-material vehicles, this project is perfectly aligned, well scoped, and executed. The reviewer said to keep up the great work.

Reviewer 2:

The reviewer commented that the approach of solid state joining of materials with different melting points considered in this project is very innovative and has potential to address some of the critical challenges faced by the automotive industry working on multi-materials. The reviewer commented that it is great to see the project also addresses optimizing joining parameters for each of the OEMs interested in material system and finally technology transfer to all OEMs.

Reviewer 3:

The reviewer said that it is a good place to be because the cost of project outcome is below DOE’s target. The reviewer also reported repeatability tested.

Reviewer 4:

The reviewer commented that it would be illustrative to see an estimate of the time required to develop the information needed to join two Al alloys chosen at random, and wondered if the timeframe is days, weeks, months, or years.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer noted impressive achievement. To this reviewer, accomplishments appear to be too good. The reviewer pointed out that grain refinement in the weld at low temperature is very good.

Reviewer 2:
The reviewer commented excellent progress, and said that it will be interesting to consider joint configurations other than the lap joint (peel, etc.), and that it will be interesting to see whether the weld parameters optimized in the laboratory work well after scaling to high volume manufacturing.

Reviewer 3:
The reviewer observed a very nice mix of different Al to steel combinations, and noted good directional results showing the potential for the process. The reviewer suggested adding some microstructural characterization to the study and that this would then be truly outstanding, and that results to date look very promising.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted excellent collaboration that is even reaching out to OEMs.

Reviewer 2:
The reviewer said collaboration seems good.

Reviewer 3:
The reviewer said that collaboration is excellent, but for this reviewer the team is a bit small. It is unclear to this reviewer what is available for the common good.

Reviewer 4:
The reviewer commented on an excellent mix of OEM participation and national laboratory involvement. Honda invested a lot of money in developing the FSW mixed metal process for the Accord subframe. This reviewer further explained that it looks like this project is a repeat, hopefully to make their joint more robust.

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 computational tool development considered in the next stage of this project is very crucial. The developed tool will help in minimizing the costs for joining with improved quality and eliminate costly trial and error.

Reviewer 2:
The reviewer observed an excellent work plan and objectives for subsequent years of funding, and said to keep up the great deliverables. As mentioned previously, the reviewer would welcome including more interfacial material characterization and some specific info on tool wear/life as a function of linear friction stir scribe length.

Reviewer 3:
The reviewer inquired if there is a need to evaluate corrosion performance, and whether it is possible to incorporate adhesive joining with the proposed process. The reviewer asked if adding adhesive joining provides any additional benefits, and whether the benefits can be demonstrated on crush members.

Reviewer 4:
This reviewer liked what was understood from the PI, though it appeared that proposed future outreach is too ambitious.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that using metals of appropriate strength, thickness, and formability in a TWB is an excellent method of lightweighting. Also, combining different Al alloys with varying characteristics such as these without degradation of properties at the joint would be an extremely valuable technology to have available.

Reviewer 2:
The reviewer said that the project addresses the major barriers faced by automakers in joining multi-materials. Using multi-materials, automakers can deliver lightweight solutions for automobiles, which will in turn help improve fuel economy, reduce dependence on foreign oil and reduce emissions.

Reviewer 3:
The reviewer said that mixed metal vehicles will be a near-term lightweighting enabler for the next 5-7 years and DOE’s support for this project clearly shows a well thought-out and aligned portfolio of funded research.

Reviewer 4:
The reviewer remarked that joining is always a key consideration for use of lightweight materials.

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

Reviewer 1:
The project looks to be appropriately funded.

Reviewer 2:
The reviewer clarified that it is because others, namely GM, TWB Company, and Alcoa, are so committed to be successful.

Enhanced Sheared Edge Stretchability of AHSS/UHSS: Xin Sun (Pacific Northwest National Laboratory) - lm106

Presenter
Xin Sun, Pacific Northwest National Laboratory

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

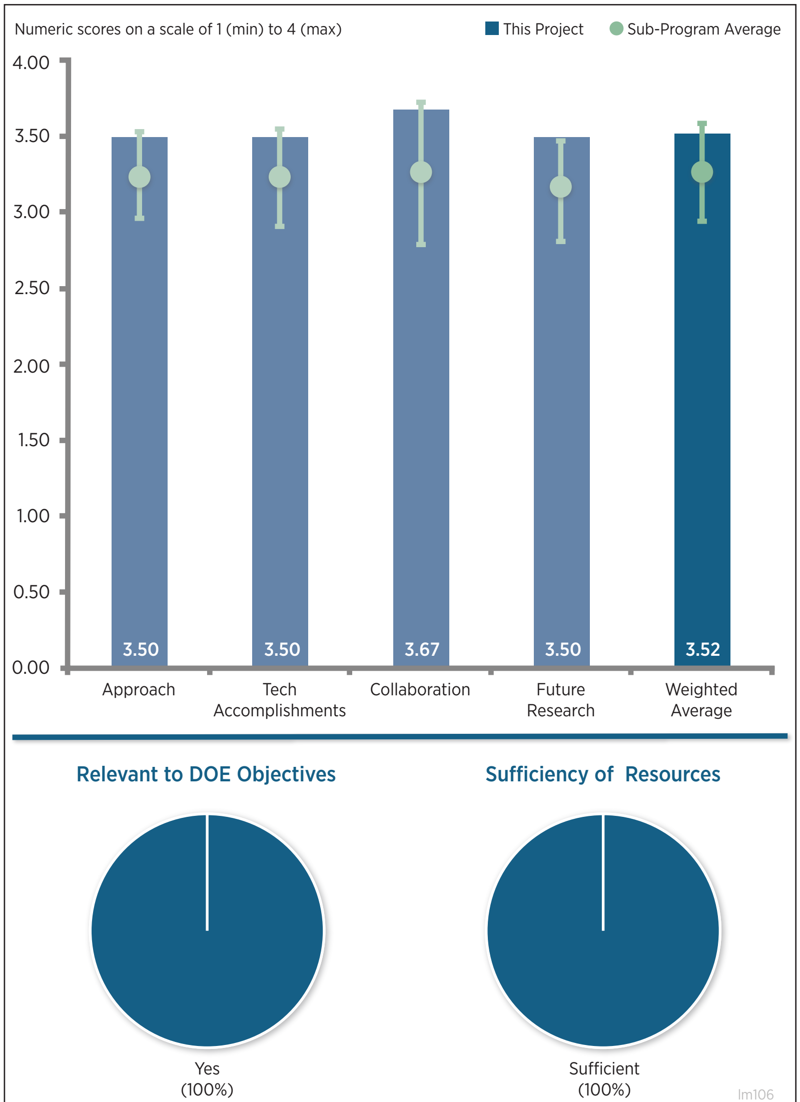

Figure 6-17 – Enhanced Sheared Edge Stretchability of AHSS/UHSS: Xin Sun (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:
The reviewer said that formability is an important parameter for formed sheet stock. Tools to predict the formability are important for the selection and adoption of new materials.

Reviewer 2:
The reviewer said that the project is a new start and the direction to develop a model directionally is a big need for shear edge trimming predictions or quality parts.

Reviewer 3:
This reviewer commented that the project will study the edge stretchability of advanced high-strength steels (AHSS)/ ultra-high-strength steels (UHSS) to increase application of AHSS/UHSS into vehicle structures for weight reduction and crash performance. The reviewer was pleased to see some numerical and physics studies other than experimental testing and characterization. The link between the material microstructure and edge stretchability is critical to guide the design and development of future generation of AHSS/UHSS.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer said that progress and accomplishments are in keeping with industry expectations.

Reviewer 2:
The reviewer said that accomplishments so far are very good, considering the project was just started in fiscal year (FY) 2015 and equipment purchase is needed before testing.

Reviewer 3:
The reviewer said that constitutive equations are sound and directionally correct, and that the project needs to deliver process models as part of the deliverables. The reviewer anticipates these results will be provided based on the strength of the team.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the selection of collaborators appears to be appropriate.

Reviewer 2:
The reviewer noted an excellent mix of industry (OEM), academia, and national laboratory participation.

Reviewer 3:
The reviewer stated that the project is well organized and distributed efficiently to different collaborators.

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 a great start, reported that the project is on track, and recommended no changes in the technical direction.

Reviewer 2:
The reviewer said that future work is well planned.

Reviewer 3:
The reviewer said that proposed future work appears to be suitable to assist in the adoption of lighter-weight structural materials.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that this will assist with the adoption of lighter-weight structural materials.

Reviewer 2:
The reviewer noted that lightweighting is not only important to traditional gasoline vehicles, but also to electric vehicles/hybrid electric vehicles for extending driving range.

Reviewer 3:
The reviewer said that AHSS and UHSS are lightweighting solutions and yet still pose challenges, and this project is an enabler for high quality parts.

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 appropriately funded.

Reviewer 2:
The reviewer said that the budget is sufficient for the project.

Optimizing Heat Treatment Parameters for 3rd Generation AHSS Using an Integrated Experimental-Computational Framework: Xin Sun (Pacific Northwest National Laboratory) - lm107

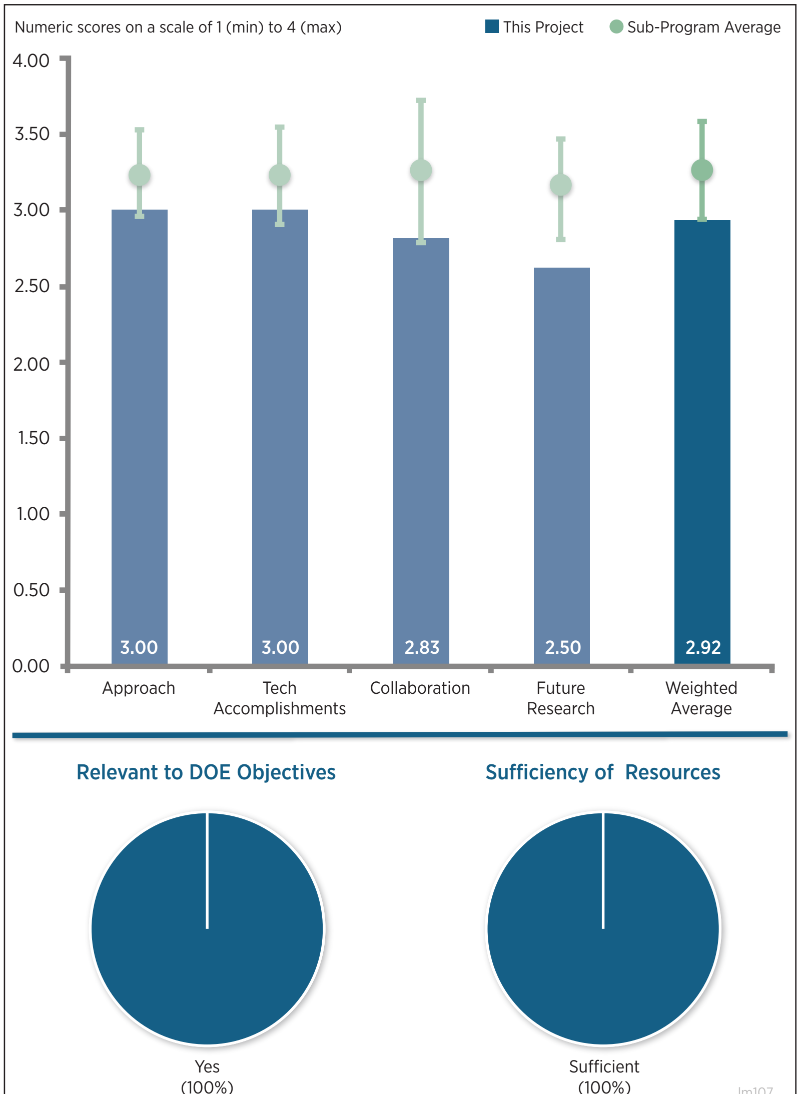

Figure 6-18 – Optimizing Heat Treatment Parameters for 3rd Generation AHSS Using an Integrated Experimental-Computational Framework: Xin Sun (Pacific Northwest National Laboratory) – Lightweight Materials

Presenter

Xin Sun, 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, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this project appears to be primarily a literature study on heat treating high manganese steels. The reviewer commented that validation data would be helpful.

Reviewer 2:

The reviewer remarked that the approach and strategy look good. It seems the team has a sound plan to approach the technical barriers.

Reviewer 3:

The reviewer said that the approach seems satisfactory. The presentation does not give clear details on the how the improvements will be found. There is good details on the testing methods. The reviewer noted that picking judicious methods in Thrust 4 is not defined. The reviewer commented that this plan for improvements seems too vague for a robust approach, and that the project team is using too many acronyms that are not generally well known. The reviewer noted that HEXRD, RA, ASPPRC, APS, IA, TRIP, TOF-SIM, and CCE are only known to material scientists, and asked that the project team please define these the first time they are used in slides or reports.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project was started early this year and many comprehensive results have been shown. The reviewer said well done.

Reviewer 2:
The reviewer said that the progress to date appears to be primarily generating models, and that more experimental results would be helpful.

Reviewer 3:
The reviewer said that this project has just started and there are few accomplishments at this time. How the experimental results will be used in the ICME models is unclear to this reviewer and has not been defined in the presentation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the collaboration and partnership appears to be appropriate.

Reviewer 2:
The reviewer noted national laboratory, university, and industry involvement, and that different parties are responsible for different tasks.

Reviewer 3:
The reviewer emphasized that there is not a clear division of labor or clear roles and responsibilities. There is an assembled team, but the project would be improved if the assignments to each member were more clear and distinct. The reviewer commented that where the experiments will be done and who will be doing the math modeling should be clearer.

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 proposed future research is appropriate.

Reviewer 2:
The reviewer said that the presentation does not have a specific slide to show the future work, but it can be seen from the tasks listed in Slide 5. The reviewer said that it is good to have the future work that will be done before the next Annual Merit Review meeting listed in a separate slide.

Reviewer 3:
The reviewer said that there is no definition of the next steps in the developments. The reviewer understands there will be testing, but the reviewer saw no details on how the specimens will be developed, or what will be done with the test results.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that this supports the acceptance on new steel alloys.

Reviewer 2:
The reviewer commented that high-strength steels might reduce the weight of future cars and trucks.

Reviewer 3:
The reviewer said that, similar to the presenter's other project, the development of lightweight material is important for energy saving and electric vehicle driving range extension.

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 budget is sufficient for the project.

Development of Low-Cost, High-Strength Automotive Aluminum Sheet: Russell Long (Alcoa) - lm108

Presenter
Russell Long, Alcoa

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

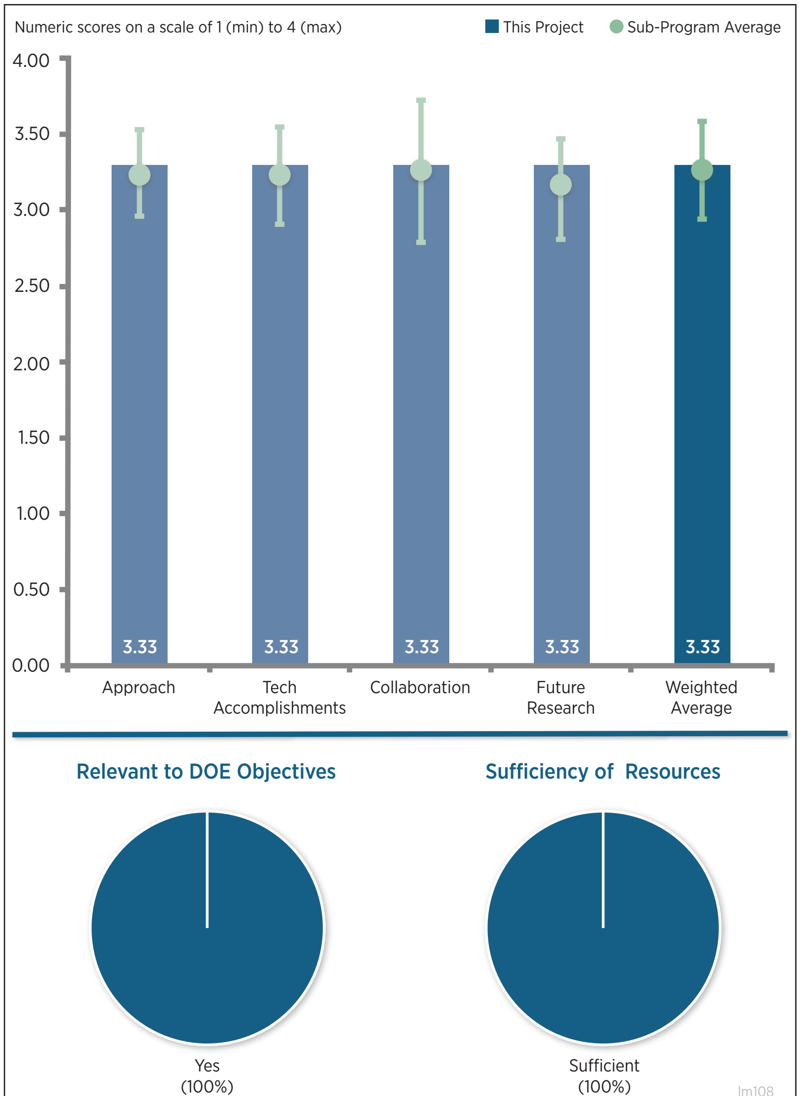

Figure 6-19 – Development of Low-Cost, High-Strength Automotive Aluminum Sheet: Russell Long (Alcoa) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:
The reviewer said that this is a large and comprehensive project being carried out by a well-qualified team and the project plan as presented was clear and goal-focused.

Reviewer 2:
The reviewer observed a good approach and project plan. The reviewer said that a weak link is demonstrating in a production plant environment with alternate objectives.

Reviewer 3:
The reviewer said that the approach to improve Al performance is well-directed. The reviewer questioned why any efforts are invested in the FSW TWB, and whether the Pacific Northwest National Laboratory (PNNL) successes can be used directly. The reviewer suggested a smaller study on the FSW blanks to confirm and repeat the PNNL learnings. Producing the full scale coils for the parts will be great. The reviewer recommended consideration of keeping or tightening the radii at the closed box ends of the project team's parts to confirm the CAE stamping/warm forming predictions all the way to splits.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer noted excellent accomplishments in this first year, and suggested that the team consider using TWB Company and PNNL for the TWB development.

Reviewer 2:
The reviewer said that accomplishments are on plan.

Reviewer 3:
The reviewer said that the presentation showed that goals are being achieved and that the project appears to be on-track toward its targets. The reviewer noted that significantly more progress is anticipated in the next phases as process equipment becomes available.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that collaboration appears to be productive, collegial, and successful. The plan clearly shows that each partner is taking an important role and one that makes sense for the total project.

Reviewer 2:
The reviewer noticed good collaboration with a vertical partnership OEM, material supplier, and Tier 1.

Reviewer 3:
The reviewer observed clear divisions of duties among the participants, and great collaboration to achieve overall project success. The reviewer suggested investigating whether the team can use the PNNL FSW for the TWB, and borrowing the lessons from PNNL tailor welded FSW blanks.

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 clear definition of the next steps to get to the target. The reviewer also wanted to see more clarity on the corrosion investigations.

Reviewer 2:
The reviewer pointed out that the portion of the presentation that dealt with future challenges was a bit brief, but showed that the team appreciates the potential barriers and that the team appears to have a plan to meet these challenges. The reviewer suspected that springback may prove to be a bigger problem than expected, however.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that the project is definitely aligned with DOE's goals.

Reviewer 2:
The reviewer said that high-strength lightweight Al is needed for future lightweight multi-material vehicles.

Reviewer 3:
The reviewer remarked that the high-strength Al will enable reduced weight of 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 said that resources look to be quite adequate.

Acronyms and Abbreviations

3D	Three-dimensional
3GAHHS	Third-generation advanced high-strength steels
AHHS	Advanced high-strength steels
Al	Aluminum
AMR	Annual Merit Review
ARPA-E	Advanced Research Projects Agency – Energy
BIW	Body in white
CAEBAT	Computer-Aided Engineering for Electric-Drive Vehicle Batteries
CF	Carbon fiber
CFC	Carbon fiber composite
CFRP	Carbon fiber-reinforced polymer
Cu	Copper
Cu_2O	Copper (I) oxide
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
FEA	Finite element analysis
FRP	Fiber-reinforced polymer (fiber-reinforced plastic)
FSW	Friction-stir welding
FY	Fiscal year
GHG	Greenhouse gas
H_2	Hydrogen
ICME	Integrated computational materials engineering
IP	Intellectual property
ISO	International Organization for Standardization
lb.	Pound
LCA	Life-cycle assessment (life-cycle analysis)
LDH	Limiting dome height
LLC	Limited liability company
MDA	Molecular dynamic analysis
Mg	Magnesium

MgO	Magnesium oxide
MMLV	Multi-Material Lightweight Vehicle
MPa	Megapascal
MSU	Michigan State University
MY	Model year
Nd	Neodymium
Nd_2O_3	Neodymium (III) oxide
NDE	Nondestructive evaluation
NDT	Nondestructive testing
NIST	National Institute of Standards and Technology
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PA	Polyamide
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
PPA	Polyphthalamide
R&D	Research and development
RTM	Resin transfer molding
RVE	Representative volume element
SMC	Sheet molding compound
TRL	Technology readiness levels
TWB	Tailor-welded blanks
UD	Unidirectional
UHSS	Ultra-high strength steels
U.S.	United States
USAMP	United States Automotive Materials Partnership
VTO	Vehicle Technologies Office