7. Lightweight Materials

The Vehicle Technologies Office (VTO) supports early-stage research and development (R&D) to generate knowledge upon which industry can develop and deploy innovative energy technologies for the efficient and secure transportation of people and goods across America. VTO focuses on research that industry either does not have the technical capability to undertake or is too far from market realization to merit sufficient industry focus and critical mass. In addition, VTO leverages the unique capabilities and world-class expertise of the national laboratory system to develop new innovations for significant energy-efficiency improvement. VTO is also uniquely positioned to address early-stage challenges due to its strategic public-private research partnerships with industry (e.g., U.S. DRIVE and 21st Century Truck Partnerships) that leverage relevant technical and market expertise, prevent duplication, ensure public funding remains focused on the most critical R&D barriers that are the proper role of government, and accelerate progress—at no cost to the Government.

The Lightweight Materials (LM) R&D area supports research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber (CF) composites, and multi-material systems to enable lighter automotive structures with performance and manufacturability that equal or exceed today's technologies. This focus area supports projects to address materials and manufacturing challenges spanning from extraction to assembly with an emphasis on dissimilar material joining, assembly technologies, and corrosion prevention that enable the use of various lightweight materials as best suited for particular applications. LM supports national laboratory research and joint work with industry through the Lightweight Materials (LightMAT) Consortium established under the Energy Materials Network (EMN).

Subprogram Feedback

The U.S. Department of Energy (DOE) received feedback on the overall technical subprogram areas presented during the 2017 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.

Presentation Number: lm000 Presentation Title: Material Technologies – Overview
Principal Investigator: Felix Wu (U.S. Department of Energy)

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

Reviewer 1:
The reviewer stated that the current program area for Materials Technology was covered very thoroughly including background, overarching strategy, focus areas and program goals. The current approach to address strategic future challenges and significant opportunities is somewhat dated; however, the presentation indicated that revisions are underway. The presentation addressed materials research that is ongoing to reach VTO goals by 2030 including the types of materials and where they will be used in commercial vehicles. The presentation also described the trend for increasing fuel efficiency using weight reduction and materials research in the area of internal combustion engines.

Reviewer 2:
The reviewer said that the strategy was well-stated.

Reviewer 3:
The reviewer commented that the program area was adequately covered for internal combustion engines. However, the scope needs to be broader to identify material challenges for electrified vehicles.

Reviewer 4:
The reviewer noted that the Materials Technology program contains two portfolios (lightweight and powertrain). The issues related to the two portfolios are presented and the outcomes from the past were discussed. The future direction of the portfolios including budget were presented. Even though the future budget is yet to be confirmed, planning for the program had been presented. Inputs were sought from participants during a separate discussion in the evening.

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

Reviewer 1:
The reviewer said that the balance between near-term and mid-term R&D is well balanced to address the challenges in materials research as defined in the VTO Multi-Year Program Plan (MYPP). The long-term R&D requirements are currently being restructured and should be based on the revision of the Materials Technology roadmap that will address any new challenges and R&D opportunities over the next 5 to 10 years.

Reviewer 2:
The reviewer observed that the objective is well balanced between near-, mid- and long-term activities.

Reviewer 3:
The reviewer suggested that the presenter provide a roadmap that shows the near-mid-long term research clearly with timeline.

Reviewer 4:
The reviewer stated that because the lightweighting portfolio is relevant even when complete electrification of vehicle propulsion occurs, it is necessary to look into the long-term future. While the work on Al alloys caters to the near- and mid-term focus, the research on Mg and carbon fiber-reinforced polymer (CFRP) caters to the long-term future. In case of powertrain materials, the reviewer remarked that the development of materials for high temperature stability is the only area of focus which will benefit in near- and mid-term goals. The program is not planning to work on long-term research.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer stated that the issues and challenges for the current program were adequately addressed and that the major accomplishments supported how the program has addressed these issues. Future issues and challenges are currently under review in order to properly structure the program to address new issues and challenges.

Reviewer 2:
The reviewer said that the benefit and importance of this program is well stated.

Reviewer 3:
The reviewer remarked that issues and challenges were addressed to some extent. The reviewer would like to see gaps and/or challenges identified and presented for existing projects moving forward.

Reviewer 4:
The reviewer noted that the fuel efficiency improvement is the major challenge; this is the focus of the two portfolios. The powertrain materials research focuses also on emissions.

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

Reviewer 1:
The reviewer remarked that plans were identified for addressing issues and challenges. The presenter addressed the current plan to update and revise the matrix for future opportunities, critical challenges, and impacts of a variety of materials and issues that may arise for incorporating materials into vehicle lightweighting projects. The presenter also stated that a meeting of representatives from industry, academia and government was being held during the Annual Merit Review (AMR) to start changes to the matrix. These inputs will assist in updating the matrix so that it can be used for development of a revised Materials Technology roadmap to aid in funding future research projects.

Reviewer 2:
The reviewer said that the future program identifies the possible areas of research for both portfolios (lightweighting and powertrain).

Reviewer 3:
The reviewer stated that no plan was presented for addressing issues and challenges.

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

Reviewer 1:
The reviewer noted that there were five areas addressed that benchmarked progress in terms of accomplishments that has occurred over the last year. In each case, the innovations and impacts of the accomplishments were detailed.

Reviewer 2:
The reviewer stated that the major achievements in five different projects were presented highlighting the past achievements. No roadmap was presented explaining the current developments against the older ones.

Reviewer 3:
The reviewer remarked that accomplishments were presented but not in an incremental manner relative to last year.

Reviewer 4:
The reviewer was not able to connect fiscal year (FY) 2017 results to FY 2016. The presenter focused too much on the innovation aspect which is "ok" but difficult to compare the progress from last 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?

Reviewer 1:
The reviewer said that the projects in the Materials Technology area are addressing broad problems and barriers in the VTO such as reducing the weight of an internal combustion engine vehicle by 10% to improve fuel economy by between 6% and 8%, and achieving a 13% improvement in freight efficiency from a 6% reduction in vehicle structural weight. Also, research in catalysts will help to improve combustion efficiencies for highly efficient gasoline engines. Progress is being accomplished through projects for lightweight metals, composites and multiple-material joining methods for these materials as well as new high temperature alloys and catalysts for more efficient combustion.

Reviewer 2:
The reviewer stated that both problems of fuel efficiency and emissions are addressed by the portfolios.

Reviewer 3:
The reviewer would like to see electrified vehicles to broaden the scope.

Reviewer 4:
The reviewer did not feel that the projects were addressing the broad problems and barriers. The propulsion material projects do not include lightweight driveline.

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

Reviewer 1:
The reviewer commented that the Materials Technology program is focused on addressing the need to provide lightweight material and propulsion systems solutions to the automotive industry that will achieve fuel savings in future vehicle designs. The Integrated Computational Materials Engineering (ICME) efforts demonstrated excellent collaboration between academia, the national laboratories and industry (original equipment manufacturers (OEMs) and suppliers). Considering the small budget for the number of projects, the program appears to be well managed and is very effective in achieving the goals in the current VTO MYPP.

Reviewer 2:
The reviewer agrees that the program appears to be focused, well-managed, and effective.

Reviewer 3:
The reviewer stated that the focus for both portfolios is on Integrated Computational Materials Research and computer aided decision making. The work on CFRP may be over extended with many projects during the review process.

Reviewer 4:
The reviewer remarked that the group headcount of two persons was insufficient to achieve a focused, well-managed portfolio.

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 noted that the key strength of projects in this program is the focusing on the correct material solutions for addressing lightweighting of vehicle structures and combustion engines. An additional strength is the highly effective collaboration between academia, national laboratories and industry that is resulting in good transition of lightweight materials technologies and ICME products to the automotive industry. The weaknesses of projects in this program are the lack of defined transitions in certain areas of propulsion materials and the slow execution of specific projects; e.g., a 2013 FOA project that has only reached 50% of its goal after 4 years of research. Projects are normally not funded for more than 5 years.

Reviewer 2:

The reviewer identified the key strength as reducing cost and weight using a multiple-prong approach. The primary weakness identified was not including electric vehicles (EVs) to reduce the weight (e.g., cables or motor).

Reviewer 3:

The reviewer identified the key strengths as the work on development of ICME tools for metals, and low-cost CF. The reviewer identified the key weakness as the joining of CFRP with other metals using mechanical joining. The destruction of CF reduces the effectiveness of joining. This has been understood for a long time but still there are a few projects or tasks studying this effect.

Reviewer 4:

The reviewer noted the key strengths as an understanding that progress is made with a vertical supply chain project team. The primary weakness identified by the reviewer was that the funding awards include large consortium projects which include many universities, several DOE national laboratories, several OEMs and several suppliers. Felix even stated "the Friction Stir Welding project is a great demonstration of a well-balanced project team, which delivers results."

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

Reviewer 1:

The reviewer noted that in some cases the approach is very novel. For example, joining methods for dissimilar metals using high temperature fusing technology and tailored welds, ICME design and crash validation of structural components made of lightweight metals and composites, and next generation three-way catalysts to improve combustion efficiency at lower temperatures.

Reviewer 2:

The reviewer stated that the approach taken for the projects is quite unique and would forward to seeing future progress in the next meeting.

Reviewer 3:

The reviewer commented that some projects are quite innovative in the use of current testing and computational expertise. The examples include the hydrogen intake in Mg and ICME of steel alloy development.

Reviewer 4:

The reviewer said that these projects represent novel and/or innovated ways. The reviewer further noted that ICME and science-based projects have achieved incremental progress.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:
The reviewer remarked that, for the projects presented, there was outstanding collaboration between academia, the national laboratories, manufacturers, automotive partnerships, and first-tier suppliers. The slides that showed the organizations' logos and described the program partnerships is an excellent example of collaboration. The description of the Lightweight Materials Automotive Consortium is another good example of how to connect industry with a network of 10 national laboratories.

Reviewer 2:
The reviewer stated that the program has engaged appropriate partners.

Reviewer 3:
The reviewer said that overall, the number of partners involved in the projects is healthy. However, in some projects the partners do not contribute significantly to technical expertise of other resources. The partners seem to get involved only for in-kind cost contribution.

Reviewer 4:
The reviewer said that the program has engaged appropriate partners, just too many on the same project.

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

Reviewer 1:
The reviewer stated that, based on the technology transitions described, the program appears to be collaborating very effectively in the majority of the projects. This appears to be occurring with hardware as well as software developers and suppliers.

Reviewer 2:
The reviewer considered it difficult to comment due to limited information.

Reviewer 3:
The reviewer did not feel the program collaborated with partners effectively. The lack of staff (two total) does not enable sufficient time to collaborate.

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

Reviewer 1:
The reviewer noted that the only possible gap would be the current lack of definition and prioritization of research efforts in the Materials Technology Program for the next 5 to 10 years. With the potential for reduced budgets, it is important that the proper areas of research be defined to allow funding to be applied in those areas. Hopefully this will be resolved with the revision to the significant opportunities and critical challenges matrix.

Reviewer 2:
The reviewer would prefer to see the scope extended beyond internal combustion engines.

Reviewer 3:
The reviewer said that a major review of the current state-of-the-art may be needed. The last review was done a few years ago.

Reviewer 4:
The reviewer identified driveline and technology projects to overcome commercialization barriers as the key gaps.

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

Reviewer 1:

The reviewer noted that the overview presentation did not allow time for a description of the full Materials Technology portfolio. In general, all areas of materials research (metals, CF and composites, methods of multiple-material joining, integrated computational materials engineering, high temperature materials, and materials to improve propulsion systems) adequately address the needs to meet VTO goals.

Reviewer 2:

The reviewer identified life cycle analysis (LCA) as a topic not adequately addressed. Cradle to grave analysis needs to be part of every project. This methodology identifies CO_2 associated with production, use and recycling. Every recipient must be forced not to ignore LCA.

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

Reviewer 1:

The reviewer noted that the program is described as addressing problems with well-known materials (Al, Mg, high-strength steels, and CFs) where automotive manufacturers and first-tier suppliers have the most interest. Future materials will use nanotechnology to provide better properties and characteristics that will be applicable to the automotive industry. The reviewer suggested that some investment should be made in those areas to further meet or exceed VTO programmatic goals.

Reviewer 2:

The reviewer recommends considering EVs.

Reviewer 3:

The reviewer noted that the research on propulsion materials to reduce emissions will be useful.

Reviewer 4:

The reviewer identified the area of lightweighting relative to driveline and transmission systems. Demonstrating efficiency related to mass reduction versus general engine downsizing should be considered, which results in 6% for every 10%.

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

Reviewer 1:

The reviewer stated that the current approach is very good for addressing near-term and mid-term barriers and challenges. New challenges will prevail for the long-term over the next decade and the program should be prepared to address them. Research organizations that are developing cutting-edge technologies should be solicited for input as to what will be the future generation of materials and how they may apply to VTO future goals. Until there is an update to the VTO MYPP, this may be a difficult task.

Reviewer 2:

The reviewer commented that the course being taken by the current team is good; international collaboration and funding to support could improve the pace of research.

Reviewer 3:

The reviewer would like to see a broader view of the material technologies in terms of the roadmap along with describing the challenges associated with each area. The reviewer said that less focus should be placed on describing innovations.

Reviewer 4:

The reviewer recommended LCA as a new way to approach the barriers, using metrics such as total manufactured cost at volume of 100,000 or 250,000 units per year.

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

Reviewer 1:

The reviewer remarked that, overall, the Materials Technology program is very effective. A few of the projects have poor execution and should be re-directed to better meet the goals and milestones of the research. Some projects do not have transition partners identified in the early stages of the projects and the principal investigators should be encouraged to identify partners in the first year of their projects.

Reviewer 2:

The reviewer recommended increasing the size of the group in order to better manage and engage with projects instead of simply monitoring them. The program MUST stop funding of several programs which have not met go/no-go objectives.

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 7-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
lm080	Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly	Lou Hector (USAMP)	7-14	3.83	3.33	3.83	3.50	**3.54**
lm084	Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM)	Anthony Coppola (Ford Motor Co.)	7-17	2.63	2.75	3.13	2.25	**2.70**
lm087	Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair, and Assembly	Mahmood Haq (Michigan State U.)	7-20	3.38	3.38	2.75	N/A	**3.29**
lm089	High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications	Robert Hilty (Xtalic Corporation)	7-23	3.00	2.70	2.70	2.90	**2.80**
lm098	Brazing Dissimilar Metals with a Novel Composite Foil	Tim Weihs (Johns Hopkins U.)	7-27	2.60	2.40	2.10	2.25	**2.39**
lm099	High-Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks	Piyush Upadhyay (PNNL)	7-31	3.60	3.60	3.70	3.10	**3.55**
lm101	Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles	Xuming Su (Ford Motor Co.)	7-34	3.33	3.33	3.50	3.33	**3.35**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
lm103	E. coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors	Randy Lewis (Utah State U.)	7-38	2.88	2.88	2.75	2.50	**2.81**
lm104	Solid-State Body-in-White Spot Joining of Aluminum to AHSS at Prototype Scale	Zhili Feng (ORNL)	7-40	3.67	3.33	3.50	3.17	**3.42**
lm105	Friction Stir Scribe Joining of Aluminum to Steel	Piyush Upadhyay (PNNL)	7-43	3.30	3.40	3.70	3.20	**3.39**
lm106	Enhanced Sheared Edge Stretchability of AHSS/UHSS	Kyoo Choi Sil (PNNL)	7-47	3.40	3.40	3.40	3.00	**3.35**
lm107	Optimizing Heat Treatment Parameters for Third Generation AHSS Using an Integrated Experimental-Computational Framework	Xin Sun (PNNL)	7-51	3.13	2.88	3.13	3.00	**2.98**
lm108	Development of Low-Cost, High-Strength Automotive Aluminum Sheet	Russell Long (Arconic)	7-54	3.50	3.38	3.25	3.00	**3.34**
lm109	High-Throughput Combinatorial Development of High-Entropy Alloys for Lightweight Structural Applications	Jeroen van Duren (Intermolecular)	7-58	2.75	2.75	3.00	2.75	**2.78**
lm110	*In-Situ* Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy	Aashish Rohatgi (PNNL)	7-62	2.60	2.60	2.40	2.50	**2.56**
lm111	Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys	John Allison (U. of Michigan)	7-66	3.25	3.25	2.88	3.25	**3.20**
lm112	Cost-Effective Magnesium Extrusion	Scott Whalen (PNNL)	7-70	3.38	3.38	3.00	3.25	**3.31**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
lm113	Magnesium Corrosion Characterization and Prevention	Mike Brady (ORNL)	7-73	3.50	3.50	3.38	3.38	**3.47**
lm114	Friction Stir Scribe Joining of Carbon Fiber Reinforced Polymer to Aluminum	Blair Carlson (General Motors)	7-77	2.50	2.83	3.33	2.67	**2.79**
lm115	Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites	Dave Warren (ORNL)	7-80	3.33	3.50	3.67	N/A	**3.48**
lm116	Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites	Leo Fifield (PNNL)	7-83	3.25	3.13	3.25	4.00	**3.28**
lm117	Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications	Venkat Aitharaju (General Motors)	7-86	3.38	3.38	3.38	3.38	**3.38**
lm118	Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly	Srikanth Pilla (Clemson U.)	7-90	3.50	3.33	3.33	3.17	**3.35**
lm119	Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration	Nate Gravelle (TPI)	7-93	3.00	2.67	3.00	2.67	**2.79**
lm120	Ultra-Light Door Design	Tim Skszek (Vehma International)	7-96	3.60	3.60	3.50	3.30	**3.55**
lm121	Carbon Fiber Technology Facility	Dave Warren (ORNL)	7-100	3.25	3.63	3.75	3.25	**3.50**
lm122	Close Proximity Electromagnetic Carbonization (CPEC)	Felix Paulauskas (ORNL)	7-104	3.13	3.25	2.88	2.88	**3.13**
lm123	Safety Statistical Analysis	Tom Wenzel (LBNL)	7-108	3.10	3.00	3.40	3.25	**3.11**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Overall Average				3.19	3.15	3.18	3.04	3.15

Presentation Number: lm080
Presentation Title: Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly
Principal Investigator: Lou Hector (USAMP)

Presenter

Lou Hector, USAMP

Reviewer Sample Size

A total of three reviewers evaluated this project.

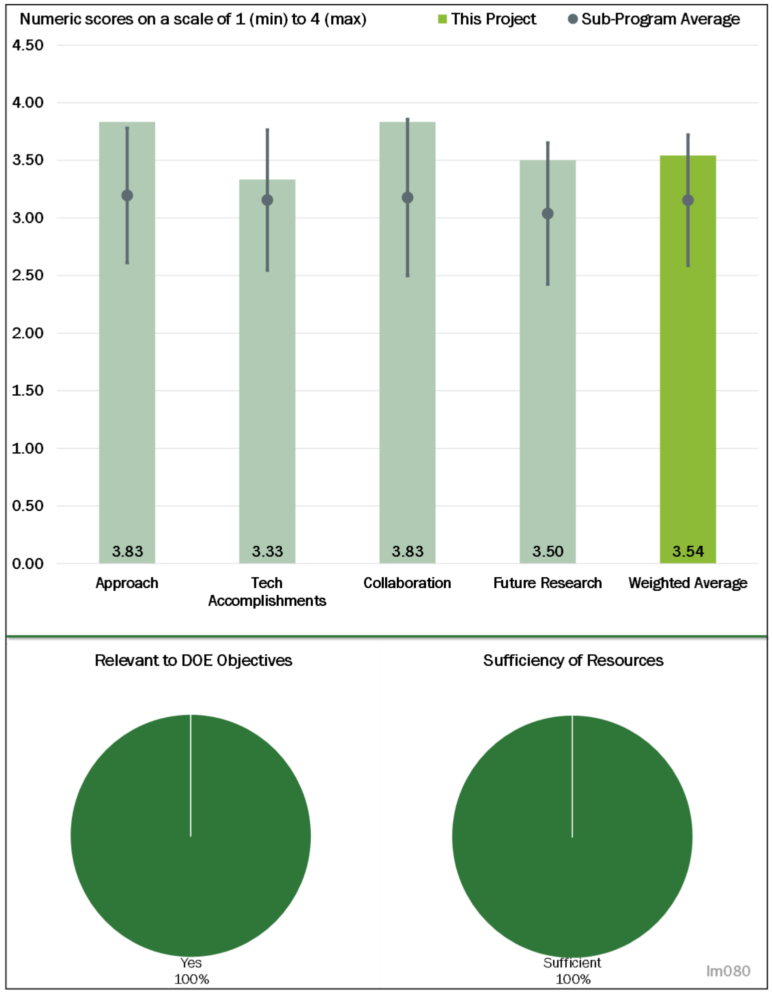

Figure 7-1 - Presentation Number: lm080 Presentation Title: Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly Principal Investigator: Lou Hector (USAMP)

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 praised this project as having an outstandingly solid approach to address technical barriers, challenges, and viability for use of third-generation advanced high-strength steels (3GAHSS) in automotive structures. The reviewer agreed that it is a highly collaborative effort with automobile manufacturers, steel companies, universities, and national laboratories that has greatly contributed to the feasibility of completing the project successfully. Additionally, the reviewer remarked that the project is fully integrated with other efforts and that the approach includes all of the elements for successful research and project management such as experimentation, modeling, fabrication, design optimization, and cost analysis.

Reviewer 2:

The reviewer affirmed that this project has a superb execution of a very complex and unexplored area of computational materials engineering as it relates to 3GAHSS.

Reviewer 3:

The reviewer remarked that the project has a good approach gaining consensus within the scientific community, and added that this is a great challenge.

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:
This reviewer affirmed that the project has been highly successful in meeting performance indicators (milestones) within the timeframe and funding requirements. The reviewer also attested that it has fully demonstrated the ability to meet project and DOE program goals for lightweighting performance and cost per pound saved when these materials are used for automotive parts. The reviewer observed that all 11 milestones were met with the exception of one that was redirected. In addition, the reviewer found that the project has demonstrated the ability to produce 3GAHSS materials with high ductility and strength in a production environment; and formulate two material recipes, an effective ICME model, and a technical cost model. Finally, the reviewer concluded that the project successfully met DOE goals for a 35% mass savings and a $3.18 cost per pound, in addition to meeting other project objectives.

Reviewer 2:
The reviewer praised the project's excellent use of Argonne National Laboratory and synchrotron beamline to characterize phases and teach ICME models that will have future use in advanced steel alloys by design.

Reviewer 3:
The reviewer asserted that the project was completed without disclosing cost per pound saved and added that this is totally unacceptable. The reviewer remarked that the actual result is much lower than the DOE objective, adding that this lack of compliance with DOE objectives must be noted.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised this project is an outstanding example of collaboration and coordination with five universities, one national laboratory, four steel companies, three automotive OEMs, and two engineering firms. The reviewer declared that this project is the best example of collaboration for any of the projects presented at the AMR.

Reviewer 2:
The reviewer remarked that this project has done a great job in collaboration with universities and DOE national laboratories.

Reviewer 3:
The reviewer commented that while there were almost too many collaborators to manage, nevertheless the project leader did an excellent job managing a complex and diverse group of engineers and scientists.

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 stated that the project is in its final year and added that the expectation is for DOE to offer future funding opportunity announcements (FOAs) to further development in ultra-high strength steels (UHSS).

Reviewer 2:
The reviewer noted that the project ended March 31, 2017.

Reviewer 3:
The reviewer remarked that there is much work yet to do in this area and offered that the project must identify in more detail what need be done.

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

Reviewer 1:
The reviewer offered that this project supports the overall objectives of DOE's VTO of reducing vehicle assembly weight and costs per pound saved which will, in turn, both reduce U.S. dependence on imported petroleum and increase fuel economy. The reviewer added that a 35% weight reduction in a vehicle assembly part can result in a significant displacement in the use of petroleum.

Reviewer 2:
UHSS will drive low cost weight savings and when coupled with other DOE-funded projects, the reviewer said, increasing competitiveness of U.S. industries.

Reviewer 3:
The reviewer observed that cost-effective mass reduction capable of high-volume manufacturing is the objective.

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 project has ended; however, the resources in terms of funds and coordinating partnerships were adequate to meet the stated goals and objectives. The reviewer added that this four-year project with a total budget of $8.5 million including cost-share had several major accomplishments for the available resources.

Reviewer 2:
The reviewer found that this project was appropriately resourced and delivered all milestones.

Reviewer 3:
The reviewer stated that many participants were directed by DOE to address this activity.

Presentation Number: lm084
Presentation Title: Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM)
Principal Investigator: Anthony Coppola (General Motors)

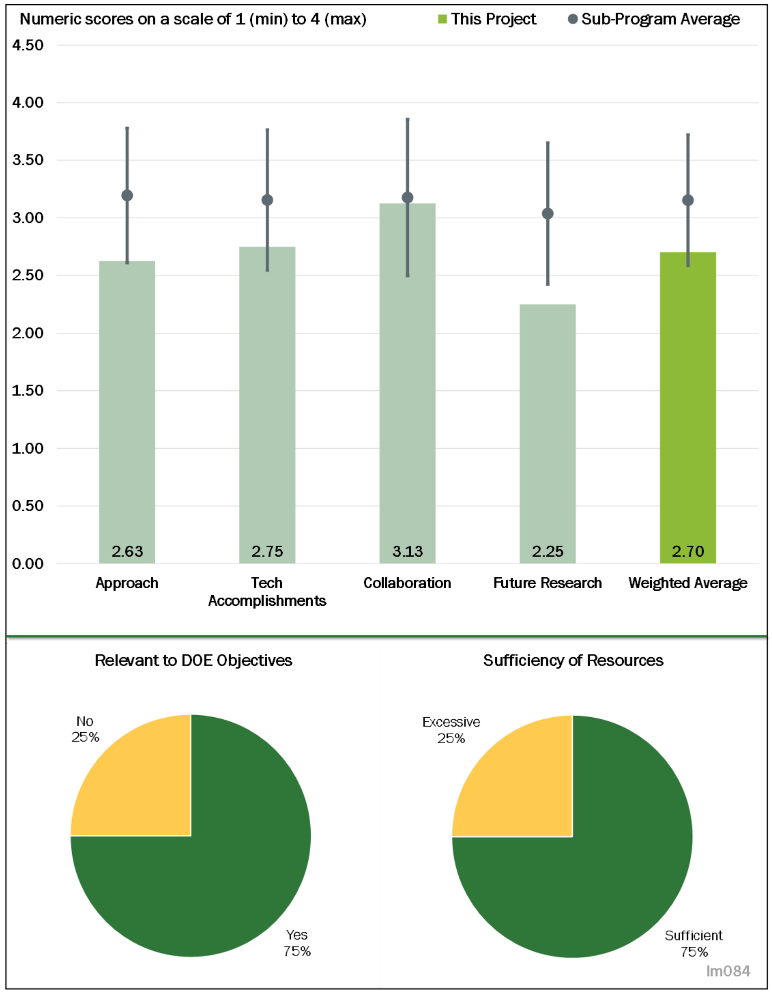

Figure 7-2 - Presentation Number: lm084 Presentation Title: Validation of Material Models for Crash Simulation of Automotive Carbon Fiber Composite Structures (VMM) Principal Investigator: Anthony Coppola (General Motors)

Presenter

Anthony Coppola, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that material model validation for crash behavior prediction of automotive CF composite structures is a critical research area because of its commercialization potential. The reviewer praised the project for its excellent combination of approach that has been considered consisting of physical tests, computer-aided engineering (CAE) activity, and validation.

Reviewer 2:

This reviewer noted that the project was established to interrogate specific CAE codes and evaluate the effectiveness based on the code, the analysis supplier, and the crash mode. The reviewer added that the single element used in the detailed analysis was well thought out. This reviewer believed that more constraints in establishing the analysis parameters (i.e., consistent material properties, boundary conditions, etc.) should have been applied so that consistency in the modelling technique was established and a more critical view of the code could be completed but concluded that otherwise, it was very well done.

Reviewer 3:

The reviewer indicated that no barriers were addressed.

Reviewer 4:

While affirming the understanding that the front bumper will be lighter, this reviewer was not convinced that its crash performance is better than the current one. The reviewer would have liked to have seen comparisons between the bumpers as a function of time (weight and performance) to have a better idea of the progress.

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 that non-destructive evaluation (NDE) of front bumper ribs was compared against both experiment versus predictions of five commercially-available codes. The reviewer stated that the accuracy level obtained between the CAE tools and experiments varied as one would expect but that how the accuracy level varied with various crash modes and software used was highlighted.

Reviewer 2:

The reviewer agreed that the project completed its stated goals, outlined the technical gaps, and provided recommendations for improvement in CF-based structural CAE for crash analysis. However, the reviewer remarked that the project as a whole would have increased its value if more work was done to identify the specific details of the analysis output to include failure modes predicted versus those observed in high speed crash experiments. The reviewer further remarked that is well-recognized that capturing the mechanics of failure in these transient response analyses is critical to accurate results and added that hopefully more of this information is included in the final reports.

Reviewer 3:

This reviewer observed that everything of the proposal seems to have been accomplished, but questioned whether it has been.

Reviewer 4:

The reviewer stated that nothing was accomplished.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer favorably commented that this project, if nothing else, included a broad set of participants across the supply chain and academic world. The reviewer cited the use of multiple material suppliers, software firms, and respected university programs, noting there was a solid tier-one firm as well as a firm specializing in software development and NDE, adding that it was all well done.

Reviewer 2:

The reviewer praised the collaboration of this project as a model for all these lightweighting projects.

Reviewer 3:

The reviewer praised as excellent the collaboration and coordination with more than 15 institutions and as having helped in achieving a successful project completion. However, the reviewer remarked that it was not apparent what were specific contributions made by each institution to the overall project.

Reviewer 4:

This reviewer stated that this project has resulted in nothing since 2012 and has not been halted by go/no-go decision points.

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 stated that this kind of research should be continued and extended.

Reviewer 2:
The reviewer stated that the project is scheduled to be completed by the end of June 2017 and added that ICME techniques may be considered to improve accuracy by predicting material property variations resulting from manufacturing imperfections.

Reviewer 3:
The reviewer warned that we must learn from the negative experience of this project.

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

Reviewer 1:
The reviewer agreed that this project supports the overall DOE objectives of petroleum indirectly by developing tools to facilitate the acceptance of automotive CF composite structures.

Reviewer 2:
The reviewer stated that weight saving is important and added this is very relevant to DOE objectives.

Reviewer 3:
The reviewer offered that clearly, the goal of displacing the use of petroleum is dependent upon many factors, however, chief among them is vehicle weight reduction, elaborating that whether the vehicle is a conventional internal combustion engine (ICE), hybrid-ICE or plug-in battery electric vehicle (BEV), weight is critical. The reviewer explained that the use of reinforced polymer systems in vehicle design has a demonstrated ability to drive weight out of the structure of the vehicle. However, the reviewer clarified that the use of any materials system in a complex structural design demands high fidelity CAE tools that accurately capture structural response in the variety of crash situations identified for safe operation. The reviewer concluded that this project sets the industry on a path to identifying the capability of the existing state of the art.

Reviewer 4:
The reviewer declared that nothing was accomplished other than engaging 17 companies and USAMP for 5 years.

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

Reviewer 1:
The reviewer stated that while this was an ambitious project with many individual stake holders, it is clear the team accomplished a tremendous amount of work. Well-funded and well-conceived, the reviewer concluded that it would appear the government was well served and the intent of the work completed.

Reviewer 2:
The reviewer found that in view of the accomplishments, it appears that resources were sufficient, but added it was hard to be sure since the project has ended.

Reviewer 3:
The reviewer stated that resources for the project is insufficient only if the five-year project performance is considered and offered that a future project should consider a shorter timeframe, similar to some of the existing demonstration projects.

Reviewer 4:
The reviewer remarked that resources were extensive, involving 17 companies and three OEMs and nothing was accomplished over 5 years.

Presentation Number: lm087
Presentation Title: Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair, and Assembly
Principal Investigator: Mahmood Haq (Michigan State University)

Presenter

Mahmoud Haq, Michigan State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

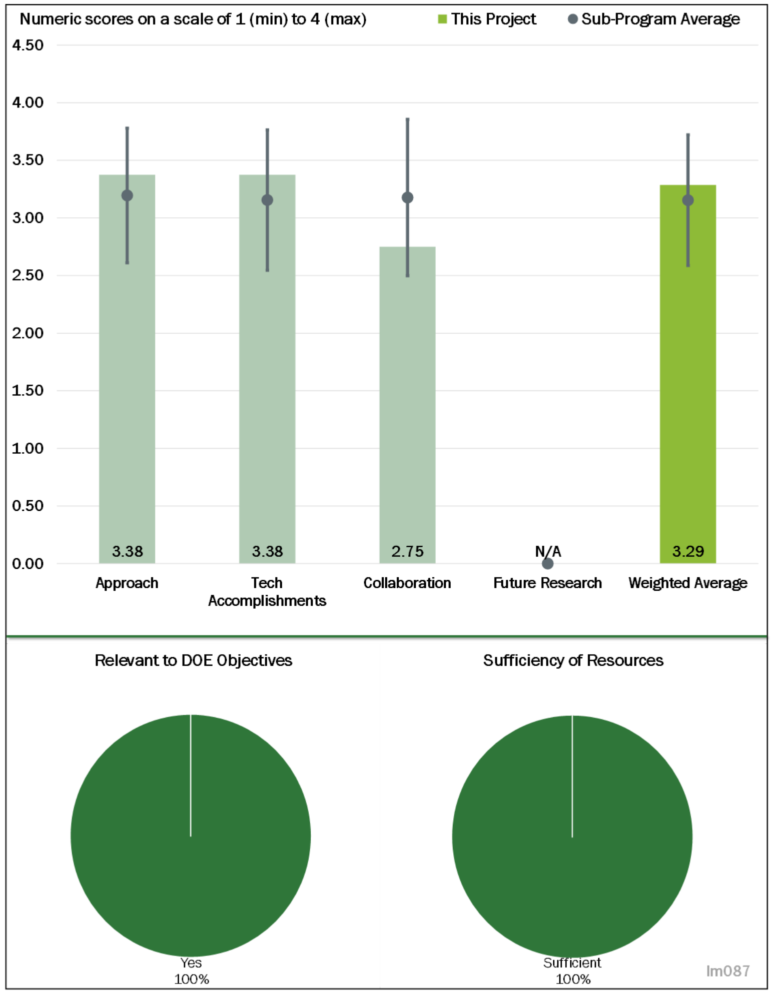

Figure 7-3 - Presentation Number: lm087 Presentation Title: Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair, and Assembly Principal Investigator: Mahmood Haq (Michigan State University)

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:

Observing that there were eight technical gaps identified for this project, the reviewer praised the approach as excellent because it included materials development and optimization, laboratory evaluation and experimental characterization, tool and database design, and data dissemination to demonstrate the feasibility of active adhesive technologies for structural joining of dissimilar materials. The reviewer found that the approach fully integrated both experimental and computational methods to investigate bonding, repair, and assembly.

Reviewer 2:

The reviewer affirmed that a great approach was taken to try and achieve the best of both worlds in mechanical and adhesive technologies but added that additional surface treatment techniques could have been evaluated to determine if one performs more efficiently than others. Stating there was not much else that came to mind to change, this reviewer suggested perhaps use of similar surface treatment for typical adhesives, etc., for comparisons.

Reviewer 3:

The reviewer remarked that the approach could focus on specific applications to prove the technology.

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:
Noting that the project demonstrated the joint strength of this new technology, the reviewer praised this as impressive.

Reviewer 2:
The reviewer said there were very successful results and the goal was achieved as defined in the scope. The reviewer praised the great job on the project.

Reviewer 3:
The reviewer explained that this project focused on 8 of 15 key technical gaps identified by DOE that contribute to delays in adoption of designs utilizing lightweight materials that support DOE goals for reducing U.S. dependence on petroleum and developing energy-efficient transportation technologies. Elaborating that the technical accomplishments and progress proved successful adhesive bonding, dis-bonding, and re-assembly of multiple lightweight materials, the reviewer agreed that the project successfully developed various adhesives for three methods of joining lightweight materials.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the collaboration during this project was limited to a corporate research organization and a national laboratory with interest from the U.S. Army. However, the reviewer noted that the presenter stated that since the project has ended, they have entered into collaborations with three OEMs and an industrial supplier of adhesive materials.

Reviewer 2:
The reviewer stated that this was a single university project and other universities did not appear to be involved. While there was some industrial collaboration, the reviewer suggested targeting a real product and working closely with industry.

Reviewer 3:
The reviewer remarked that it would have been nice to have OEM participation to go after a specific joint design relevant to their applications.

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 stated the project has ended.

Reviewer 2:
The reviewer suggested that there should be some follow up on commercialization of the technology.

Reviewer 3:
The reviewer noted that this project ended in March 2016 and expressed surprise that the principal investigator (PI) was asked to present at the 2017 AMR.

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

Reviewer 1:

The reviewer explained that this project focused on 8 of 15 key technical gaps identified by DOE that contribute to delays in adoption of designs utilizing lightweight materials that support DOE goals for reducing U.S. dependence on petroleum and developing energy-efficient transportation technologies and agreed that it had relevant results to support these goals.

Reviewer 2:

Remarking that permanent bonding of adhesive is a huge barrier preventing their adoption into production, the reviewer stated that this project overcomes that barrier.

Reviewer 3:

The reviewer said yes, this project has relevance in enabling vehicle lightweighting.

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

Reviewer 1:

The reviewer said that the goal was met in a timely manner.

Reviewer 2:

The reviewer agreed that $600,000 for a performance period of 2-1/2 years was sufficient for the university to conduct the needed research, adding that the remaining work is dissemination (publication) of results.

Reviewer 3:

The reviewer had no comments on this finished project.

Presentation Number: lm089
Presentation Title: High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications
Principal Investigator: Robert Hilty (Xtalic Corporation)

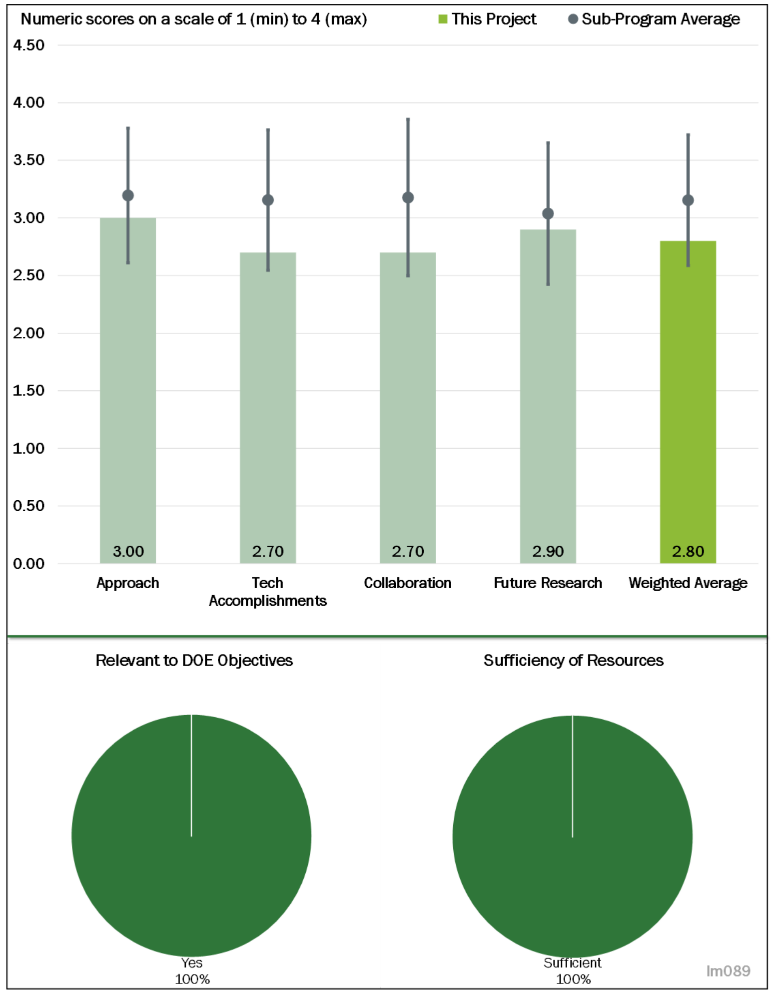

Figure 7-4 - Presentation Number: lm089 Presentation Title: High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications Principal Investigator: Robert Hilty (Xtalic Corporation)

Presenter

Robert Hilty, Xtalic Corporation

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 agreed that the approach adopted contributes to achieving most if not all of the stated goals of the work.

Reviewer 2:

The reviewer remarked that the novel approach to making Al was very interesting and noted that manganese (Mn) boost is needed to increase strength. The reviewer wondered how increasing the Mn content (somewhere between 7% and 10%) will increase material and/or processing costs, and whether the Mn content will preclude joining processes such as fusion (spot) welding and thereby requiring some type of fastening process if used in vehicle components. The reviewer suggested that some thought is needed on this all-important topic.

Reviewer 3:

The reviewer noted that the project is aimed to develop Al sheet; however, the approach is to develop a coating process to deposit a nanostructured Al alloy atop an Al alloy core and added that the Issue of interface performance need to be addressed. The reviewer remarked that the use of this technology on top of Mg sheets could be a potential growth area but that it needs to be seen in the performance of the composite sheet, adding that this is not included in the current work plan.

Reviewer 4:

The approach is good and promising and this could be promising material, the reviewer stated, but warned that the plan is ill conceived. The reviewer explained that the Al core is basically an Al foil and since those come oxidized, corrosion and delamination could become real problems for this kind of material. The grading relates to the fact that this reviewer likes the initial idea of fabricating sheets with such technology.

Reviewer 5:

While the approach begins to address the technical barriers, the reviewer stated that the lack of a pilot on a continuous plating process is disappointing. Noting that the leap from 6"x6" plates to a continuous coil process is substantial, the reviewer wondered when the continuous process will be addressed. Finally, while agreeing that the plating experiments on the additives appear promising, the reviewer cautioned that both the strength and ductility are under performing at this point, meaning that the project needs to improve grain size to improve properties.

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 good progress has been made and that the project appears on course to completing the work on time and achieving the state goals.

Reviewer 2:

The reviewer praised the excellent progress, noting that the project appears to be on track towards the $2.00/lb. saved target. However, the reviewer remarked that some question remains as to whether or not the requisite mechanical properties will be achieved. In addition, regarding the demonstration door beam in Slide 3, the reviewer wondered if some type of shape/geometry optimization will be conducted to determine the appropriate cross-sectional geometry that leads to the highest structural stiffness or instead will a steel beam geometry be used. The reviewer cautioned that some thought on this would be wise. The reviewer then asked a series of questions. First, the reviewer asked if some ultimate limit to the thickness of material that can be produced, for example, is 800 microns (µm) the de facto upper bound on material thickness. Secondly, the reviewer asked how often (if ever) the ionic liquid needs to be changed, and what are the cost implications. And thirdly, the reviewer noted that a forming limit diagram (FLD) will be needed, especially if a door beam is to be designed, and asked if this is planned.

Reviewer 3:

The reviewer noted the major achievement in this review period is the successful scaling up to 6"x6" panel but cautioned that the quality of the sheet and the size of it need to be improved, adding that the current thickness of 50-µm is way out of the target of 400-µm per side. The reviewer also pointed out that the technical cost modeling reveals the cost is still in technology and not much is explained to reduce the current cost which is nearly three times the target.

Reviewer 4:

Agreeing that there is steady though slow progress towards the goals, the reviewer expressed concern that the mechanical properties have degraded with this year's larger sample size, adding that the true strength of these samples is lower than the 2016 results. The reviewer also noted that the progress on thickness and double-sided plating appears to be behind schedule, adding that it is unclear how the 6"x6" test informs the design of a full-scale reactor. The reviewer pointed out that the effects of the jets is likely to be much different at scale and wondered how the moving plate with a boundary layer will be addressed.

Reviewer 5:

While stating that overall progress is satisfactory, the reviewer expressing dissatisfaction with the answer on corrosion as "nano-Al alloys have excellent corrosion resistance due to single phase..." This reviewer expressed a desire to see thorough experiments to prove this statement, especially since there are two interfaces on an oxidized Al-6061 core. Moreover, this reviewer does not believe that there can be a "perfect bond" without treating the Al foil accordingly to remove the surface impurities. The reviewer warned that the fact that there is no mention on how to prepare the Al for the coating is a real problem, adding that the project called for an Al-6061 core but the shown tests are on brass foil.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that parties to this work include Fiat Chrysler Automobiles (FCA) and Tri-Arrows Al, adding that these companies are listed as subcontractors, which suggests they are being funded to perform certain well-defined tasks. The reviewer said that most of the work appears to have been done by Xtalic, and concluded that they are fairly well-coordinated and the partnership seems to work well.

Reviewer 2:
The reviewer remarked that even though there are two other participants in this project, their role is limited to technical advice and material supply. The bulk of the work is still conducted by one of the partners. The reviewer stated that this is understandable due to the evolving nature of the technology and creation of intellectual property (IP), but noted more involvement in the base technology to validate the chemistry and process route chosen.

Reviewer 3:
The reviewer commented that while the cooperation appears to be effective, there is little mention about in-process collaboration. The reviewer noted that the information on Slide 19 lists responsibilities but says nothing of interactions or collaboration.

Reviewer 4:
Noting that the collaboration involves Xtalic, FCA, and Tri-Arrows Al, the reviewer wondered who is going to do the simulation for the sheet forming that is mentioned on Side 23. The reviewer added it was unclear which of the three companies will do this.

Reviewer 5:
The reviewer concluded that collaboration is not extended enough and appears to be solely for the benefit of one OEM.

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 stated that the proposed work is fairly straightforward and, if successful, should address the barriers and challenges identified. However, the reviewer commented that risk mitigation is not addressed and consequently no alternate development pathways are identified.

Reviewer 2:
The reviewer commented that there is a section on proposed future research, but it just repeats what the project plan states.

Reviewer 3:
The reviewer cautioned that it is unclear what is to be done with the sheet given the success of the project regarding forming. The reviewer asked if this is to be left to another project.

Reviewer 4:
Remarking that this appears to be a very promising material, this reviewer is surprised to find almost no relevant comments on corrosion, stability with respect to time, temperature, flexing and bending, delamination, etc., adding that generating all this information should have been planned ahead of time and will have to be obtained before such a promising material can be used in automotive applications. The reviewer also commented that the target of $2/lb. saved can only be realized if the material satisfies all the required

specifications for automotive applications and given all the needed works to be done, expressed doubt that it can be realistically achieved.

Reviewer 5:

Noting that the aim is to develop a nanostructure Al sheet having at least 1-millimeter (mm) thick, the reviewer remarked that the current plan does not identify the route to achieve this and further warned that the time available (through Dec 2018) might not be sufficient to develop the new set up to do the work.

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

Reviewer 1:

This reviewer agreed that the project supports the overall DOE objectives of displacing petroleum by reducing the mass of automotive structures.

Reviewer 2:

The reviewer said yes, this project supports the overall DOE objectives of petroleum displacement.

Reviewer 3:

The reviewer remarked that Al sheet can be used for critical parts if the strength of it can be improved to match high-strength steels, and this project is aimed to achieve this goal. Using the low weight Al vehicles can save fuel. The reviewer commented that if the ultimate goal of coating Mg sheets with Al is achieved, then the savings could be improved further.

Reviewer 4:

The reviewer agreed, but only for specific places where the potentially additional strength is needed.

Reviewer 5:

Noting that the project addresses weight reduction and cost effectiveness in components, the reviewer remarked however that the quantification of the overall improvements in the presentation is rather limited.

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 sufficient budget is allocated to address the project needs.

Reviewer 2:

The reviewer is unsure if there are suitable resources for examining formability of the Al-Mn sheets.

Reviewer 3:

The reviewer stated that while the cost to develop and scale up might be just sufficient, the timeline is too short to achieve the full potential.

Reviewer 4:

While sufficient for what has been achieved, the reviewer concluded that the resources are inadequate in view of all the additional and necessary work and testing needed to certify such material for the industry.

Reviewer 5:

The reviewer remarked that without having access to financial data and the statement of work (e.g., hours needed to accomplish tasks, charge rates, and materials cost), it is difficult to make this assessment accurately and added that there is also no matrix/presentation of data on money spent versus work done to assist.

Presentation Number: lm098
Presentation Title: Brazing Dissimilar Metals with a Novel Composite Foil
Principal Investigator: Tim Weihs (Johns Hopkins University)

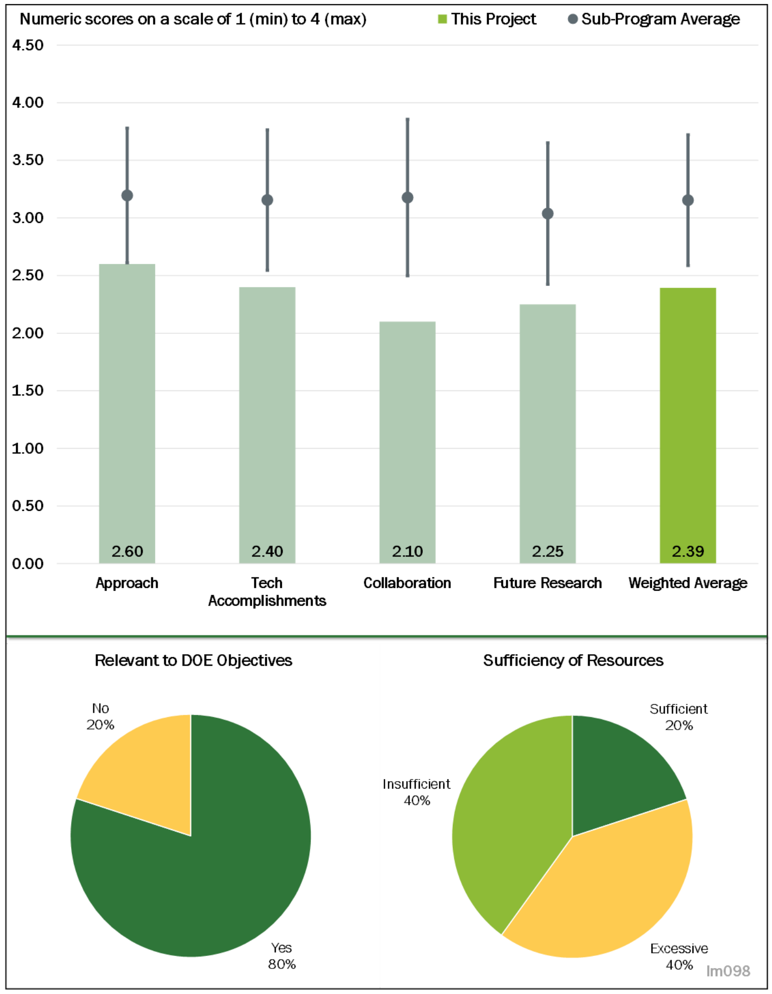

Figure 7-5 - Presentation Number: lm098 Presentation Title: Brazing Dissimilar Metals with a Novel Composite Foil Principal Investigator: Tim Weihs (Johns Hopkins University)

Presenter

Tim Weihs, Johns Hopkins University

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer affirmed that the technical barrier associated with joining of the dissimilar metals in the light weight components for auto assembly has been well addressed with a focus on the brazing technique. The reviewer added that several novel fabrication methods have been considered as well as remaining challenges and barriers have been addressed.

Reviewer 2:

The reviewer said that while the approach to overcoming technical barriers was good, the results fell short of the initial goals. The reviewer elaborated that the project was well-designed for early-stage research on novel materials for brazing dissimilar metals. Noting that this is a unique approach to joining dissimilar metals and is considered as an alternative to other technologies. The reviewer acknowledged that there is little potential for integrating with other efforts.

Reviewer 3:

While agreeing the approach is sound, the reviewer judged the tie to a high-volume solution as nebulous, adding that the additions of copper and silver, while chemically attractive, could lead to corrosion and cost trouble, respectively.

Reviewer 4:

The reviewer strongly declared that the approach was flawed.

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 explained that the objective of this project was to enable new multi-material joining techniques to introduce more lightweight components for auto assembly and to develop and characterize novel reactive foils for bonding dissimilar materials. The reviewer further explained that the project identified the gaseous species during propagation of reactions; produced vapor-deposited metal composite foils with five different diluent amounts in order to identify an idealized microstructure and with impact verified by modeling; and reduced the solidification temperature on cooling by over 100°C by replacing the copper diluent with silver. The reviewer determined that research objectives were met successfully against the performance indicators and the research demonstrated some progress towards meeting DOE goals, although the technical goals for the strength of the joints was not met due to issues with joint heating and porosity of the bond. The reviewer added that values for joint strengths were lower than anticipated and there was some evidence of potential corrosion. Nevertheless, the reviewer concluded that the project still produced some good results for the initial studies on this novel composite foil joining method.

Reviewer 2:

The reviewer stated that the project addresses the DOE vehicle mass reduction goal by addressing the issue of joining dissimilar metals. The reviewer noted that several novel reactive foils for use in bonding of dissimilar metals have been examined but challenges still remain to be addressed in order for commercialization.

Reviewer 3:

The reviewer commented that technical accomplishments have steady but slow for this year with the team creatively addressing barriers as they arose. The reviewer remarked that project is progressing but it appears that more troubles are surfacing with each step forward. Nevertheless, the reviewer concluded there have been good efforts to reduce boiling by including copper into the ball milling process, adding that the promising results from Japan are encouraging.

Reviewer 4:

The reviewer stated that nothing was accomplished.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that because this is a fairly small-sized project, collaboration and coordination with other institutions have been somewhat limited.

Reviewer 2:

The reviewer commented that while collaboration has improved, there is room for further improvement to address the bond strength and corrosion issues.

Reviewer 3:

The reviewer noted that collaboration was primarily within academia with some involvement of two material suppliers and some interest from the U.S. Army. The reviewer suggested that the lack of collaboration with automobile manufacturers or parts manufacturers was possibly because the project was in the early stages of research and will end in December 2017.

Reviewer 4:

The reviewer said there was no 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 stated that the future work proposed addresses some of the challenges revealed during this phase of work and added that the current phase of work is expiring by the end of calendar year (CY) 2017.

Reviewer 2:

The reviewer observed that the project will complete in December 2017 (i.e., in 6 months) and that proposed future work is to incorporate a new material in the bonding process, optimize bonding parameters, investigate bond strengths and modes of failure, adding that analysis of bonds will have many risks and challenges to overcome in order to demonstrate that this bonding technique can meet DOE goals. However, the reviewer noted that risks and alternative development pathways, other the current approach, was not discussed during the presentation.

Reviewer 3:

The reviewer stated that the team has identified the upcoming challenges and has developed future work plans to address the challenges. However, the reviewer concluded that the efforts to address corrosion potential seem less than adequate to address the issue.

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

Reviewer 1:

The reviewer agreed that the project addresses the overall DOE objectives of petroleum displacement by addressing one of the challenges of joining of dissimilar lightweight automotive materials.

Reviewer 2:

The reviewer replied yes and elaborated that if the project is successful and a novel method is developed for effectively joining dissimilar lightweight metals without inducing defects that enhance corrosion, then one barrier that contributes to delays in adoption of designs utilizing lightweight materials that support DOE goals for reducing U.S. dependence on petroleum will be overcome.

Reviewer 3:

The reviewer stated that this project addresses joining of dissimilar metals, a major enabler for lightweight vehicles, but cautioned that this is still very early research.

Reviewer 4:

The reviewer exclaimed there is zero joint strength, and corrosion issues.

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 almost $600,000 has been invested in academic research over 4-1/2 years with results falling short of meeting DOE goals but added that this is more in line with fundamental or basic research that does not have to produce a product to transition to industry.

Reviewer 2:

The reviewer concluded that the resources allocated for this four-year project seem to be insufficient to meet the overall project objectives.

Reviewer 3:
The reviewer stated that the resources do not appear to be adequate to address the bond strength, potential corrosion, cost, and implementation issues that are anticipated.

Reviewer 4:
The reviewer urged that these projects need to be stopped at early go/no-go decision points.

Presentation Number: lm099
Presentation Title: High-Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks
Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

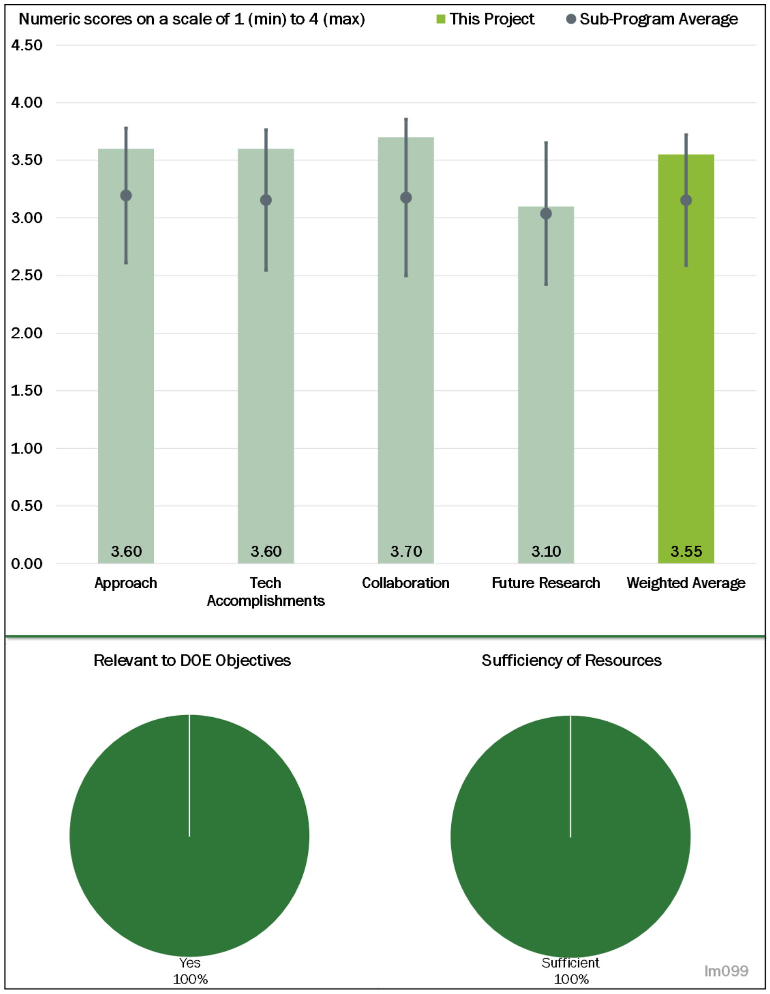

Figure 7-6 - Presentation Number: lm099 Presentation Title: High Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

Presenter
Piyush Upadhyay, 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 described this as an excellent project that is well-coordinated between Pacific Northwest National Laboratory (PNNL), industry (General Motors [GM]), and supplier (TWB Company) with a very relevant topic of next generation joining of Al sheets using friction-stir welding (FSW).

Reviewer 2:
The reviewer praised the approach as outstanding with clear steps to address the industrial needs for this technology and added that by including the FLD and the Barlat coefficients, this study is very valuable to industry.

Reviewer 3:
The reviewer affirmed the approach as good and the number of welds per combination is very impressive.

Reviewer 4:
The reviewer commented that there was a very good approach by a qualified team.

Reviewer 5:
While remarking it is a great approach to overcoming the technical barriers, the reviewer questioned the reasoning behind the 7xxx series aluinums chosen since these are not typical alloys for automotive applications and the stamping properties are not optimized. Acknowledging that the proof of concept is still being performed, the reviewer also questioned the welding parameter changes when going to, for instance, a 7055.

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 praised the technical accomplishments as exemplary and characterized the efforts on repeatability and investigation of tool life as particularly impressive, adding the team has done great work.

Reviewer 2:
The reviewer described the results-to-date as excellent with limiting dome height (LDH) forming trial looking promising. The reviewer suggested the team consider extending to make like production stamping trials on door inner panels in order to complete proof of process.

Reviewer 3:
The reviewer praised the very good accomplishment.

Reviewer 4:
The reviewer affirmed that progress is good and on track.

Reviewer 5:
While agreeing that accomplishments are right on track to meeting the goals, the reviewer expressed concern that the stamping of the 7075 and 7085 may not perform to expectations but added that this should not be an issue meeting production readiness as alloys will constantly change in the future.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer characterized a great mix of industrial lead (GM), laboratory led (PNNL), and supplier supported (TWB Co.) process development, adding that the new PI did an excellent job picking up from previous PI in a seamless transition and continuation of the project.

Reviewer 2:
The reviewer remarked that the collaboration between the welding supplier, GM, material supplier, and national laboratory leverages the strengths of each organization to produce an impressive result with strong interactions and great teamwork.

Reviewer 3:
The reviewer stated that for the tasks and goals, the team is comprised of the right folks to push this through to a production-ready scale.

Reviewer 4:
The reviewer praised it as a great example of DOE national laboratory and industry collaboration.

Reviewer 5:
The reviewer described collaboration as too restrictive, adding that there should be more than one OEM on such 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 affirming that the proposed future research addresses the remaining hurdles for the project.

Reviewer 2:
The reviewer stated that the project is completed.

Reviewer 3:
The reviewer suggested extending the work to include 7xxx Al alloys and FSW to 5xxx and 6xxx sheet products.

Reviewer 4:
The reviewer remarked that future research should be as planned but with more statistics included, pointing out that the plots shown have no error bars. The reviewer added that typical standard deviations should be included in plots and if the error bars are within the thickness of the graph line, then this should be specified.

Reviewer 5:
The reviewer explained that the lower rating is only due to the 7xxx series selected and the concerns with stamping, adding that the results will be interesting to see if an optimal weld for these material combinations can be met.

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

Reviewer 1:
The reviewer stated that this provides a new and more efficient way to join these high-strength aluminums which are needed to reach VTO requirements, adding that the process will also be applicable to other areas of the vehicle for joining sheet Al that have not even been discussed.

Reviewer 2:
The reviewer remarked that the tuning of weight to meet performance needs is a critical element of vehicle lightweighting and that by having tailor-welded Al blanks in our tool box, further mass reductions are possible. The reviewer added that mass reduction directly reduces the amount of petroleum used.

Reviewer 3:
The reviewer commented that Al will drive weight savings in large trucks and sport utility vehicles (SUVs) and it meets the objectives of DOE's VTO.

Reviewer 4:
The reviewer offered that if this intended in replacing steel parts, then definitely, but probably not in replacing other Al parts. Instead, the reviewer said that cost savings are more evident.

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

Reviewer 1:
The reviewer characterized this as a good use of DOE and industrial resources.

Reviewer 2:
The reviewer stated this had sufficient resources for the project and planned work.

Reviewer 3:
The reviewer replied the project is appropriately funded.

Reviewer 4:
The reviewer replied the resources may or may not be sufficient.

Presentation Number: lm101
Presentation Title: Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles
Principal Investigator: Xuming Su (Ford Motor Co.)

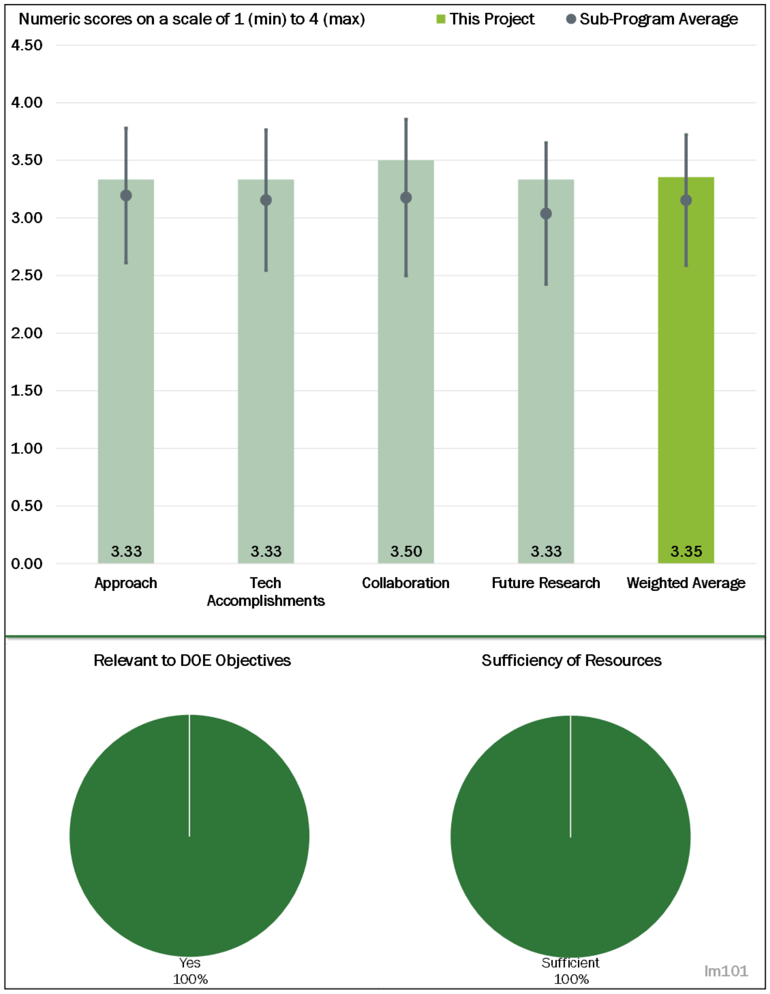

Figure 7-7 - Presentation Number: lm101 Presentation Title: Integrated Computational Materials Engineering (ICME) Development of Carbon Fiber Composites for Lightweight Vehicles Principal Investigator: Xuming Su (Ford Motor Co.)

Presenter

Xuming Su, Ford Motor Company

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 began by stating this project (LM101) is a very broad and ambitious effort that addresses key technical barriers to implementation of fiber-reinforced polymers in automotive applications and praised the contractor as having demonstrated a work plan that is very well designed and technically very sound. The reviewer elaborated that if the execution continues at the level exposed to date, the effort will generate a methodology and tool set that should support achieving the stated goals. The reviewer also explained that the fundamental characterization of the micro-scale material system is critical to successful macro-scale modeling and concluded by stating it is refreshing to see how thoroughly this is addressed, in both the fundamental material form and the analysis of post-process geometry, as well as the impact on local fiber orientation/geometry.

Reviewer 2:

The reviewer praised the excellent approach in comprehending the complexity of composites using top-down and bottom-up multi-scale modeling.

Reviewer 3:

The reviewer stated that the value of molecular dynamics (MD) simulations to predict interphase strength at crash/quasi-static strain rates is not clear and wondered if a peel strength test or an analogous test could provide the same information directly. The reviewer elaborated that it seems the MD work is sensitive to the exact chemistry of the sizing and hence, perhaps, not translatable to other sizing chemistries which are typically proprietary.

The reviewer also observed that noise, vibration, and harshness is listed in the "Overall Objectives" section of the presentation file but does not seem to have been addressed in the AMR presentation. The reviewer requested an elaboration on specimen geometry optimization for fatigue testing of chopped sheet molding compound material vis-à-vis American Society for Testing and Materials (ASTM) International/International Organization for Standardization standardized geometry. The reviewer inquired whether this project can lead to a new standardized specimen geometry if no standard exists. The reviewer mused that while the project may improve upon the predictive capability of composite performance, it is not clear how the manufacturing cycle time could be reduced. To that point, the reviewer asked if the cycle time is not directly related to resin's curing time which, in turn, is a function of temperature and hence, can be reduced only to a limit (by increasing the temperature) without degrading the fiber. Alternately, the reviewer asked what desired cycle time the team is aiming for.

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 praised the excellent technical progress accomplished and said it was nice to see that the predictions are within 10% of experimental results.

Reviewer 2:
The reviewer remarked that progress on this program was demonstrated across the multi-disciplines of activity, elaborating that from microscale modeling and representative volume element work to forming technologies and prediction of outcomes from process integration studies, the PI provided significant data and successful cross-correlation of results to prediction. The reviewer concluded that the work to date suggests a successful approach to ICME is taking shape.

Reviewer 3:
The reviewer commented that it seems predicting the fiber orientation (whether chopped fiber orientation during mold filling or continuous fiber orientation during draping) is the key to achieving good predictability of overall mechanical properties. The reviewer then wondered if, alternatively, is it possible for the team to identify which aspect of this research would be most impactful in improving the overall predictability better than 15%, even though the target for error bound is 15%. The reviewer suggested that improving the predictability may avoid over-designing the product and achieve additional weight savings and cost reduction.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised the contractor as having demonstrated strong progress with a variety of partnerships that clearly are effective in the breadth of activities accomplished. With competent university interaction, as well as material and software support, the reviewer also praised the PI for having performed significant amounts of work to include data generation, analysis, and drawing significant conclusions for work going forward. The reviewer said it was all well done.

Reviewer 2:
The reviewer described the teams as well-balanced with excellent collaboration between them.

Reviewer 3:
With such a large team, the reviewer suggested it would be useful to remind the audience how the work was coordinated (e.g., meeting schedules, internal reviews, etc.).

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 described future work as very promising to eliminate some of the barriers in predicting the performance of composite materials.

Reviewer 2:

The reviewer remarked that the PI was explicit regarding any shortcomings or failures in work to date and the gaps exposed, adding that future work has identified methods to close these gaps. The reviewer concluded that there is little reason to doubt that the contractor will be successful given the detail provided and the results to date.

Reviewer 3:

Beyond the cost of the CF, the reviewer suggested it would be useful to identify which aspect(s) of the fabrication process need to be prioritized to achieve weight savings greater than 25% with the least amount of cost increase per pound saved. Alternately, the reviewer suggested the team could plot weight savings versus cost/lb. saved to indicate the cost premium in the case that weight savings greater than 25% is desired. The reviewer commented that it is not clear how the fragmentation tests can validate MD predicted data (at strain rates 10^8 or more). Finally, the reviewer said that with a significant use of CF composites in the aerospace industry, it would be useful to clarify which aspects of modeling and fabrication in current research differ from aerospace industry and hence require additional effort beyond what is known in the industry.

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

Reviewer 1:

The reviewer replied yes, elaborating that the technology deliverables from this project have potential to lower the weight of an automobiles. The reviewer added that lowering the weight directly increases the fuel economy and thus reduces the petroleum consumption.

Reviewer 2:

The reviewer explained that successful implementation of reinforced plastics on automotive vehicles has a demonstrated, significant impact on system weight, adding that lighter platforms drive improve vehicle emissions and reduce fuel consumption. In the case of plug-in BEVs, the reviewer noted that extending range is key to successful and economically viable consumer applications (which will further displace petroleum usage). The reviewer concluded that this project clearly lays important and necessary groundwork for successful prediction and analysis and supports manufacturing of these advanced materials.

Reviewer 3:

The reviewer suggested that perhaps lifecycle analysis is needed to answer this question effectively since both the CF and the resin are based on petroleum based precursors.

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

Reviewer 1:

The reviewer enthused that resources are perfect and right on.

Reviewer 2:

The reviewer stated that while the project is tremendously ambitious in scope, the resources available are sufficient, adding that progress is on track and future work outlined is in line with remaining funds.

Presentation Number: lm103
Presentation Title: E. coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors
Principal Investigator: Randy Lewis (Utah State University

Presenter
Randy Lewis, Utah State University

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

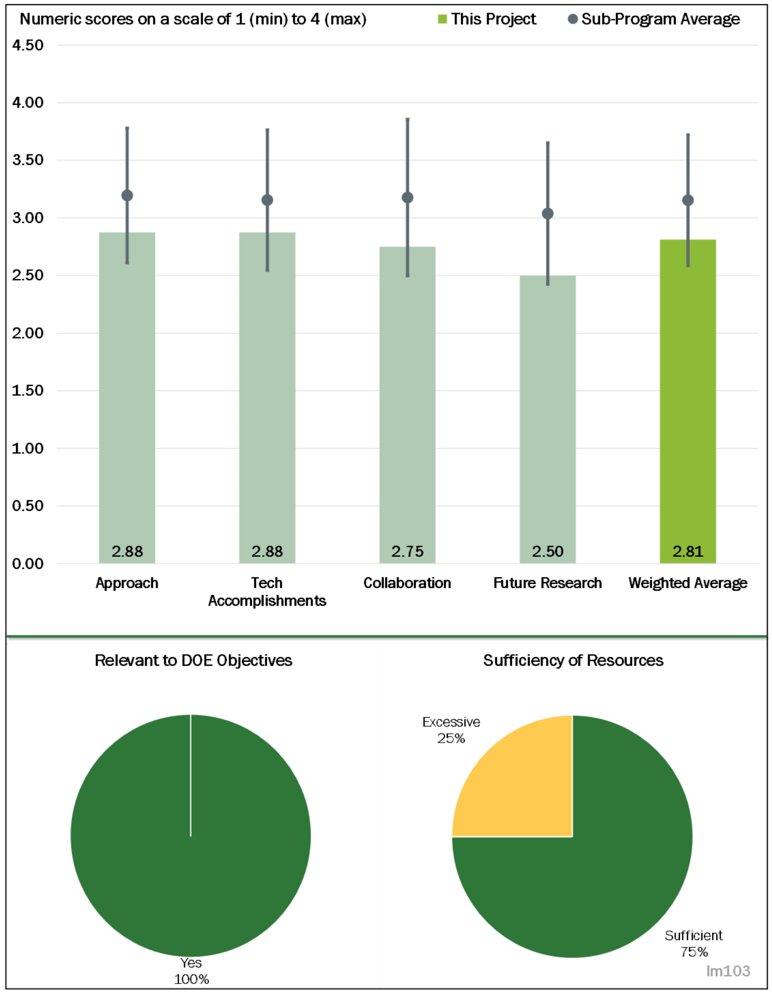

Figure 7-8 - Presentation Number: lm103 Presentation Title: E. coli Derived Spider Silk MaSp1 and MaSp2 Proteins as Carbon Fiber Precursors Principal Investigator: Randy Lewis (Utah State University)

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 characterized the project as having an interesting subject with a good approach to develop fundamental understanding from a unique group of scientists.

Reviewer 2:
The reviewer remarked that it seems for the processing temperatures, material loss during heating and the heating duration are similar to that in conventional CF processing and, as a result, it seems these barriers still need to be overcome.

Reviewer 3:
While the overall approach was good, the reviewer commented that it would have been much better if the project team established meeting go/no-go targets in development of suitable replacement for CF, adding that the final developed properties are far less than the performance of CF from stiffness

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 agreed that the project met its milestones in a timely manner, as well as produced spider silk fibers and performed the techno-economic analysis of the process. In addition, the reviewer concluded that the project demonstrated the feasibility of using E. coli-derived spider silk proteins as precursors for CF, but cautioned how easy/difficult it is to meet the cost targets is still uncertain.

Reviewer 2:
The reviewer stated that within the time allotted, the technical accomplishments seem satisfactory but that the explanation of cost impact could have been further improved with key examples.

Reviewer 3:
The reviewer said that while there is good knowledge, the commercial application is not there.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that collaboration between identified partners appeared good but questioned whether it would have been more appropriate to have other industry partners involve in addressing the overall feasibility of using such alternative precursors in automotive applications.

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

Reviewer 1:
The reviewer noted that the project is complete.

Reviewer 2:
The reviewer stated the project has ended.

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

Reviewer 1:
The reviewer remarked that the low-cost CF is a potential means of lightweighting transport vehicles.

Reviewer 2:
The reviewer suggested it would be useful for the project to identify whether any of the raw materials are derived from petroleum. The reviewer noted that the large amount of heat at high temperatures requires furnaces and wondered whether these are oil/gas-fired or electrical radiant furnaces.

Reviewer 3:
The reviewer concluded that the project by itself does not fully support the relevance of meeting DOE objectives and is of the view that additional research funding is required for flesh out the details further.

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

Reviewer 1:
The reviewer thought that the DOE share of about $1.5 million seems excessive for the scope of work presented.

Presentation Number: lm104
Presentation Title: Solid-State Body-in-White Spot Joining of Aluminum to AHSS at Prototype Scale
Principal Investigator: Zhili Feng (Oak Ridge National Laboratory)

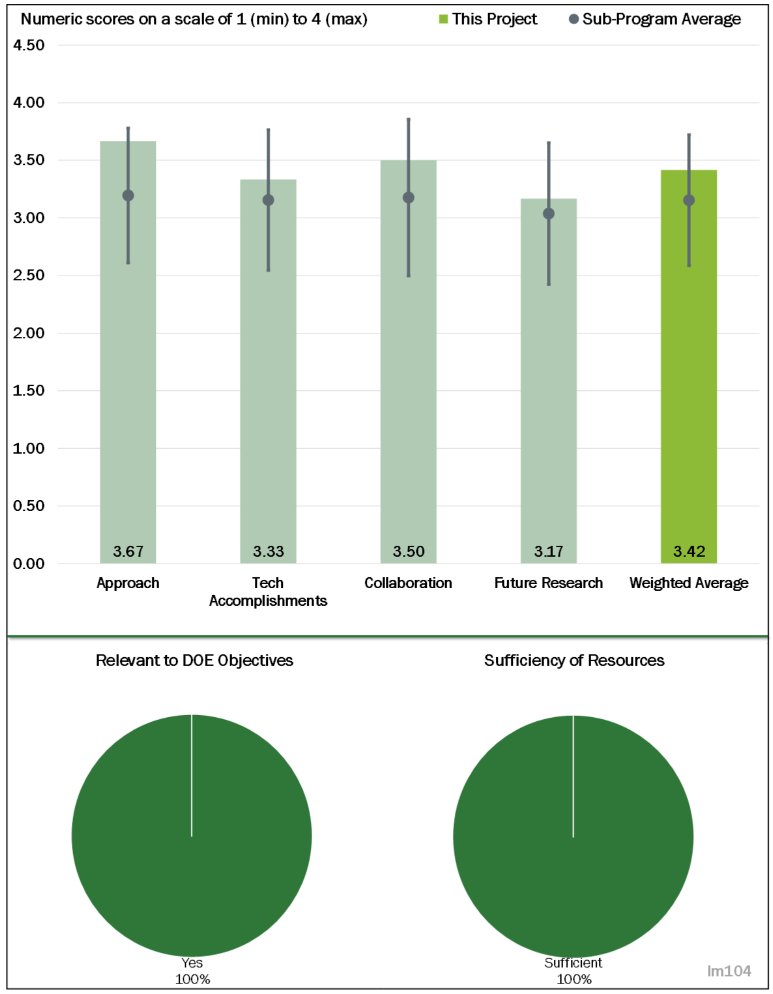

Figure 7-9 - Presentation Number: lm104 Presentation Title: Solid-State Body-in-White Spot Joining of Aluminum to AHSS at Prototype Scale Principal Investigator: Zhili Feng (Oak Ridge National Laboratory)

Presenter

Zhili Feng, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer praised as excellent the inclusion of two types of joining, friction bit joining (FBJ) and friction stir spot welding (FSSW), adding that while FSSW is considered in other projects, this particular project is also evaluating the FBJ.

Reviewer 2:

The reviewer commented that corrosion performance seems to be the most challenging barrier to overcome and should be the focus of the future work.

Reviewer 3:

The reviewer praised the good approach on a very challenging problem but added that while the joining appears to be okay, corrosion stress cracking could be the real problem for this technology.

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 replied there has been good progress.

Reviewer 2:

The reviewer praised the mechanical performance as excellent but added that the project needs to make progress on corrosion performance.

Reviewer 3:
The reviewer stated there is good progress on FBJ and the technical challenges on FSSW are being addressed but noted that the evaluation of a key factor in the process, corrosion, is delayed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised the excellent collaboration among project partners and added that industrial collaboration is also evident.

Reviewer 2:
The reviewer said it is a very good and extended team.

Reviewer 3:
The reviewer replied that all partners have taken part in the project.

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

Reviewer 1:
The reviewer noted that the project is almost complete but it would be interesting to broaden the range of applications for these techniques (i.e., FSSW and FBJ).

Reviewer 2:
The reviewer reiterated the need to focus on corrosion in future research.

Reviewer 3:
The reviewer remarked that two technical challenges identified in the project, galvanic corrosion and thermal expansion mismatch, have not been included or detailed in future research.

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

Reviewer 1:
The reviewer concurred that the project will enable the use of lightweight Al in vehicle construction, which lead to fuel economy in gasoline cars and contribute to the development of electric cars.

Reviewer 2:
The reviewer agreed that the ability of putting together light elements with strong ones will have a definite impact on petroleum displacement.

Reviewer 3:
The reviewer replied the project is enabling vehicle lightweighting.

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

Reviewer 1:
The reviewer said there is sufficient funding.

Reviewer 2:
The reviewer observed that it seems less than 50% of the budget has been used in project that is 70% (time) completed and added that the funds will be sufficient even though scale-up happens in the final stages.

Presentation Number: lm105
Presentation Title: Friction Stir Scribe Joining of Aluminum to Steel
Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

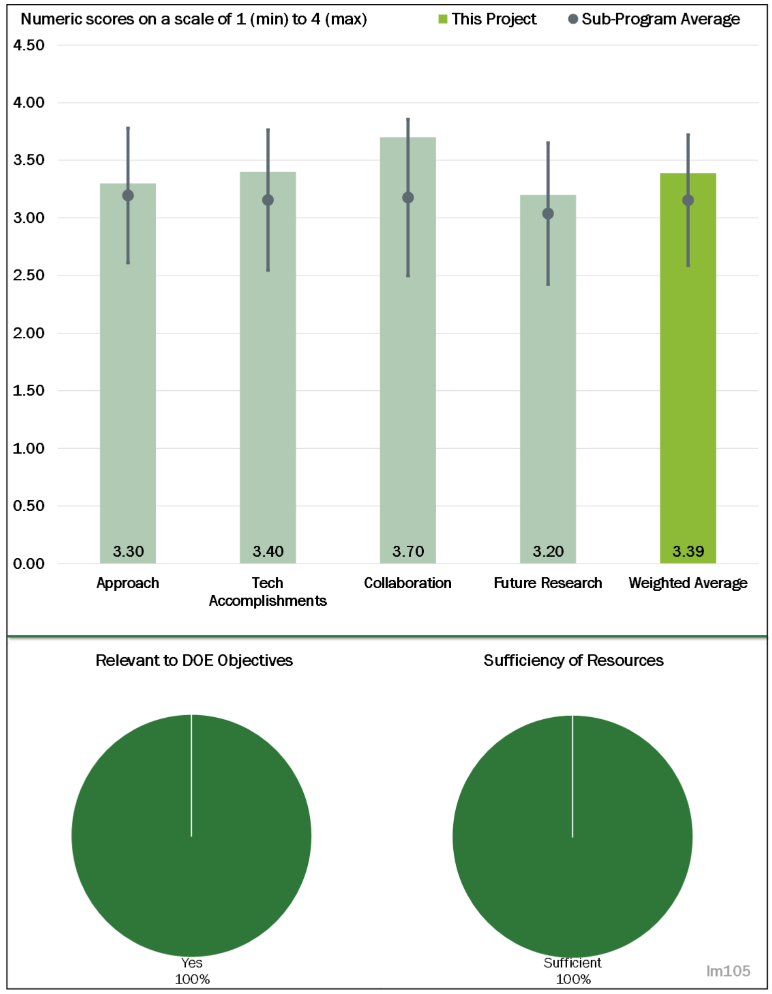

Figure 7-10 - Presentation Number: lm105 Presentation Title: Friction Stir Scribe Joining of Aluminum to Steel Principal Investigator: Piyush Upadhyay (Pacific Northwest National Laboratory)

Presenter

Piyush Upadhyay, 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 declared this to be a great project that is enabling more multi-materials into automobiles for lightweighting.

Reviewer 2:

The reviewer agreed that technical barriers are covered very well with this effort and are resulting in successful weldments. Praising the project as very well laid out, the reviewer noted it is leveraging the work of other DOE friction stir scribe (FSS) projects and applying the lessons learned to overcome current challenges. The reviewer stated this is very nice work.

Reviewer 3:

The reviewer stated the project has a good approach on a difficult problem in which corrosion could be the proverbial Achilles' heel.

Reviewer 4:

While praising the excellent approach, the reviewer remarked that too many systems in this study will minimize the success of one mix materials system. Nevertheless, the reviewer characterized this as an excellent project looking into flash-welding mixed metal joining.

Reviewer 5:

The reviewer noted that the project is evaluating the joining of different grades of steel with different Al samples (e.g., cast, wrought) and praised this as very good. However, the reviewer observed that the evaluation of some key factors such as galvanic corrosion and coefficient of thermal expansion mismatch have not been included early on in the plan and commented that the structure-property modeling is not very solid. The reviewer concluded that the evaluation of the microstructure evolution is sadly missing since this would have been an asset in understanding the effects of different steels and Al parts.

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 characterized the excellent progress, adding that three different systems from three OEMs were incorporated.

Reviewer 2:
The reviewer praised very good progress with very good results.

Reviewer 3:
The reviewer noted that the project is in its last steps for completion and transition to an OEM and explained that the technical accomplishments cover the goals set forth by DOE for dissimilar material joining. While agreeing that the OEM goals and challenges are also being met with stationary shoulder development and thermal monitoring, the reviewer commented that it would be nice to see the new material for the scribe tip and for the project to perform some welding on the higher strength steels to test if assumptions are met. The reviewer also suggested as a possible solution considering additional refractory metals.

Reviewer 4:
The reviewer remarked that the main accomplishments are on the integration of stationary shoulder in the process and the evaluation of the strength of various Al/steel joints. The reviewer also noted that a predictive structure-property model has also been initiated along with the prototype evaluation, although the latter with some delay.

Reviewer 5:
This reviewer would like to see more long-term testing of scribe life when FSW of dissimilar metals takes place when the FSW is through soft into a harder material system. Life of the scribe tool needs to be studied in more detail.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer characterized as excellent collaborations between various stakeholders.

Reviewer 2:
The reviewer praised the team as excellent with good synergy.

Reviewer 3:
The reviewer said it is nice to see multiple OEMs involved in this project to tackle a specific joint design that each is trying to achieve and added that the robotic integrator is also a nice addition as this would be one of the transition partners to get the technology implemented into production. The reviewer further commented that having this team here will really help to push this technology forward by applying to real-world applications and described as very refreshing to see such great collaboration.

Reviewer 4:
The reviewer noted the unique mix of three OEMs (GM, Honda, and FCA), each with different objectives and that PNNL is competing the tasks and milestones as expected.

Reviewer 5:
The reviewer stated that while all partners seem to be taking part, an interactive mode with the related industrial partners on materials aspects or corrosion testing is not apparent.

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 agreed that the proposed future work will permit this project to its stated final goals. However, the reviewer added that even though the corrosion work is being performed outside of this effort, it would have been nice to include it from the beginning or at least report on it.

Reviewer 2:
The reviewer stated that while the project is almost complete, it should be continued to broaden the field of applications

Reviewer 3:
The reviewer urged including more studies on scribe tool life to prove longevity and durability of the FSW tool.

Reviewer 4:
The reviewer remarked that future research should include more predictive model development for understanding the physics during the FSS joining.

Reviewer 5:
The reviewer observed that no details are given for Task 3.2 (prototypical demonstration) which is the main remaining activity (other than modeling).

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

Reviewer 1:
The reviewer stated that dissimilar material joining is going to be needed to meet the requirements set forth by DOE and is currently identified as the number one priority in many circles. The reviewer praised this this project as advancing the technology to the point of real world applications by looking at specific materials and joint configurations for three different OEMs. The reviewer remarked that the technology should be looked at as an enabler for lightweighting and one that can be applied to multiple material combinations and joint designs.

Reviewer 2:
The reviewer affirmed that the learning and deliverables from this project will enable usage of more Al in automobiles for lightweighting and thus reduce the consumption of petroleum.

Reviewer 3:
The reviewer agreed that the project will enable weight reduction in vehicle construction leading to fuel economy in gasoline cars and that it will also contribute to the body construction of electric and hybrid cars.

Reviewer 4:
The reviewer replied that combining light elements with strong ones will help in displacing petroleum.

Reviewer 5:

The reviewer answered that mix metal joining is a major enabler for future body in white and chassis subsystems

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

Reviewer 1:

The reviewer praised the project as progressing nicely and that the correct people are involved to reach completion on time.

Reviewer 2:

The reviewer agreed that project resources are sufficient to complete the project.

Reviewer 3:

The reviewer replied that this project is appropriated resourced.

Reviewer 4:

The reviewer said that no clear budget figures were presented to deduce how much of the total budget has been consumed. Noting that the project is timewise 80% completed and the FY 2016 budget is $420,000, the reviewer said it would have been good to detail the prototyping steps and the resources planned for these activities.

Presentation Number: lm106
Presentation Title: Enhanced Sheared Edge Stretchability of AHSS/UHSS
Principal Investigator: Kyoo Choi Sil (Pacific Northwest National Laboratory)

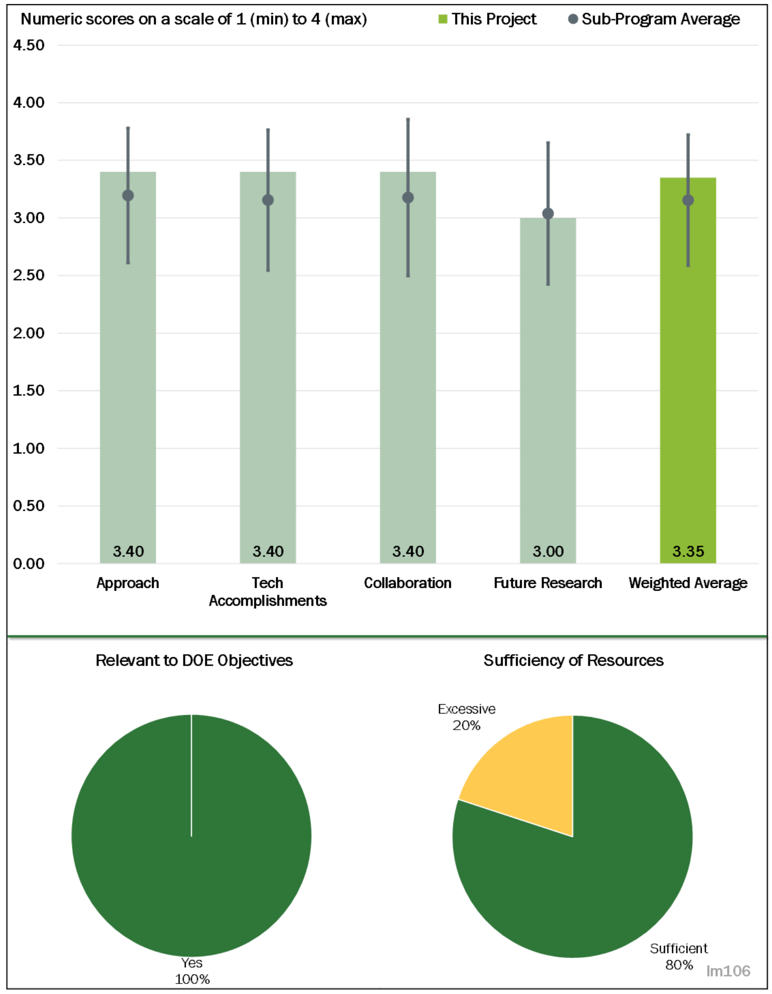

Figure 7-11 - Presentation Number: lm106 Presentation Title: Enhanced Sheared Edge Stretchability of AHSS/UHSS Principal Investigator: Kyoo Choi Sil (Pacific Northwest National Laboratory)

Presenter

Kyoo Sil Choi, 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 praised this as an excellent body of work that includes detailed microstructural characterization, fundamental modeling and forming simulation modeling of shear edge, and hole punching processes. This reviewer is very impressed with both the technical approach and level of detail in the project.

Reviewer 2:

This reviewer stated that this project has a solid, feasible approach to solving a difficult technical barrier for accepting advanced and ultra-high strength steels to be used in automotive applications. The reviewer elaborated that the project is well designed and addresses the fundamental understanding of the role of microstructure on sheared-edge stretchability, which will allow the building of predictive capabilities to quantify relationships between microstructures and trimmed-edge quality including subsequent stretchability. The reviewer added that the approach covers all aspects of initial literature reviews, material property characterization, trimming and piercing simulations and experimentation, and optimization of process parameters. The results for this project integrates well with other efforts for implementing advanced steels in automobile fabrication.

Reviewer 3:

The reviewer remarked that the project has a very good approach and the project team shows that they know what they are doing.

Reviewer 4:

The reviewer commented the approach for not including a hypothesis and being rather shotgun in nature, the result of which was that nothing was proved or disproved. The reviewer concluded that nothing more is known today than was known 4 years ago.

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 praised the technical accomplishments and progress as having been successful and significant. The reviewer remarked that the project has remained on schedule and has demonstrated progress toward meeting DOE goals by meeting all performance indicators (milestones). The reviewer affirmed that the success of this project will allow the development of next-generation steels to be accelerated and will enable a rapid and cost-effective deployment of advanced steels in vehicle structures through automobile manufacturers for substantial mass savings that meet the lightweighting goals specified in VTO's MYPP.

Reviewer 2:

The reviewer is impressed with the high-energy X-ray diffraction work coupled with the mechanical property measurements of the dual phase (DP) steels including DP1, DP2B, and DP2T 980 steels, adding that the detailed tensile data and characterization of shear edge defects is if great value to the transportation industry as it looks to use more UHSS systems.

Reviewer 3:

The reviewer stated that the progress and accomplishments are both in order with clear presentation of the results.

Reviewer 4:

The reviewer asked what was accomplished.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer enthused that the collaboration in this project is outstanding and involves a national laboratory, a university, two steel manufacturers, and an automobile manufacturer. The reviewer praised the collaborations as having resulted in shared responsibilities for experimental materials characterization at micro and macro scales, phase property and shear-affected zone characterization, predictive modeling capabilities linking microstructures to trimming conditions and edge stretchability, and optimization of microstructure and process parameters based on the ability of sheared surfaces to stretch.

Reviewer 2:

The reviewer commented there was the perfect mix of PNNL (national laboratory), steel suppliers, and industrial partners sharing in the characterization and testing of DP steels for shear edge cracking.

Reviewer 3:

The reviewer stated it was a very good team with good synergy.

Reviewer 4:

The reviewer remarked it was a good opportunity for a local university to collaborate with an OEM (Ford) and DOE national laboratory (PNNL), but emphasized that there was not too much science here.

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 explained that this project is scheduled to complete at the end of FY 2017 and that the remaining efforts (future research) include completing remaining tasks to include addressing macro fracture, stretchability and hole extrusion ration predictions and experiments; development of a computational scheme for a three-dimensional model that considers the hole edge variation effects; and optimization of process parameters and microstructures for trimmed edge stretchability. The reviewer surmised that since these are part of the original project plan and developed in a logical manner to meet decision milestones, the remainder of the project is expected to be successful and added that no further future efforts were presented.

Reviewer 2:
The reviewer stated that the project is almost over but it would be desirable that the techniques of the project be extended to other areas.

Reviewer 3:
This reviewer would like to see more R&D proctored by the PI from PNNL, who is now at Oak Ridge National Laboratory (ORNL).

Reviewer 4:
The reviewer commented that the recommendations and lessons learned are non-existent.

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

Reviewer 1:
The reviewer stated that this project is relevant and supports VTO's MYPP goals and objectives for incorporating advanced and UHSS lightweight automobile components. By meeting lightweight materials goals, the reviewer asserted that this project will also solve problems that contribute to delays in adoption of designs utilizing lightweight advanced steels that support DOE goals for reducing U.S. dependence on petroleum and efficient transportation technologies.

Reviewer 2:
The reviewer replied yes, the application of AHSS can provide cost-effective mass reduction associated with the production of high-volume vehicles.

Reviewer 3:
The reviewer answered yes because using advanced materials will reduce part weight.

Reviewer 4:
The reviewer commented that UHSS, in particular DP steels, will continue to drive lightweight vehicle body architectures and chassis subsystems as the primary low-cost weight savings options.

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

Reviewer 1:
The reviewer concluded that although this project is resourced at over $2 million for a 3-1/2 year performance period, the resources are sufficient for the number and types of organizations (national laboratory, academia,

tier 1 material suppliers, and an automobile manufacturer) that are actively involved in different aspects of the R&D needed to solve this problem.

Reviewer 2:
The reviewer stated that from the amount of work presented, resources appear to be adequate.

Reviewer 3:
The reviewer said this project was appropriately resourced.

Reviewer 4:
The reviewer commented that valuable PNNL resources were expended but with very little to show.

Presentation Number: lm107
Presentation Title: Optimizing Heat Treatment Parameters for Third Generation AHSS Using an Integrated Experimental-Computational Framework
Principal Investigator: Xin Sun (Pacific Northwest National Laboratory)

Presenter
Xiaohua Hu, Pacific Northwest National Laboratory

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

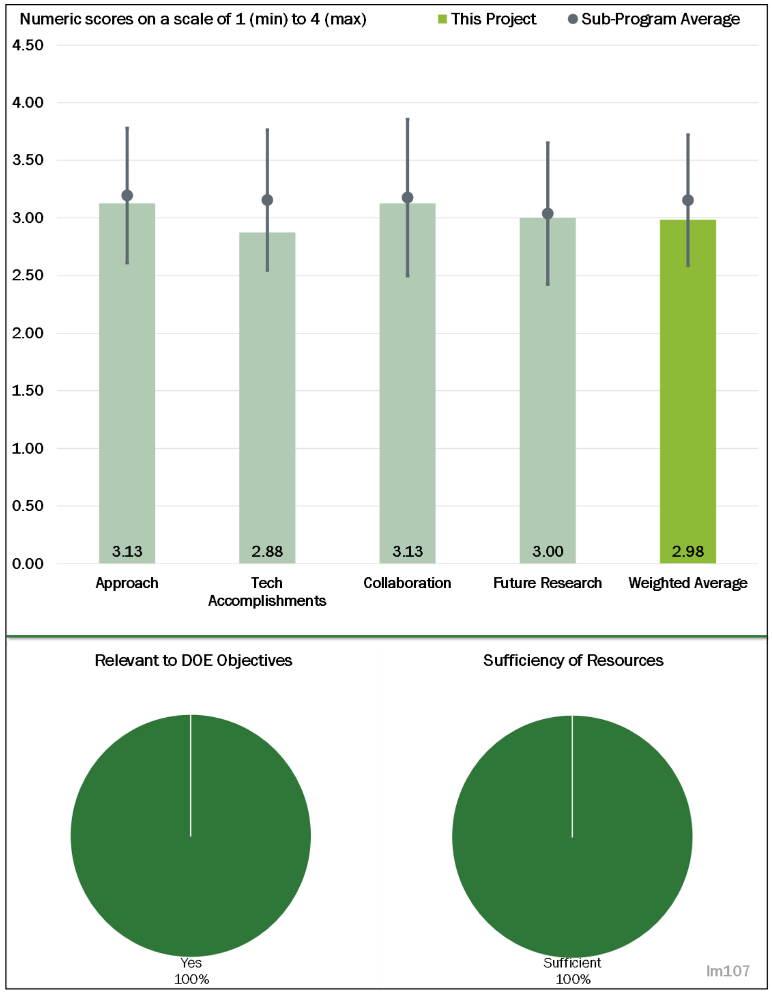

Figure 7-12 - Presentation Number: lm107 Presentation Title: Optimizing Heat Treatment Parameters for Third Generation AHSS Using an Integrated Experimental-Computational Framework Principal Investigator: Xin Sun (Pacific Northwest National Laboratory)

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:
This reviewer praised this as a great project to develop ICME of UHSS using state-of-the-art microstructural characterization and modeling tools to deliver alloys by design.

Reviewer 2:
The reviewer stated that the approach addresses the project goals and that the use of ICME should point to the best solutions. The reviewer also noted that the development of the ICME models for austenite volume fraction and microstructure evolution might help develop the processing recipes.

Reviewer 3:
The reviewer stated that the objective needs to be defined in a clearer definitive manner.

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 praised this as an excellent project and one that parallels the 3GAHSS project just completed and adds to the ICME steel alloys by design toolbox.

Reviewer 2:
The reviewer affirmed that the accomplishments are on track for the project and added that the studies are progressing well. However, the reviewer cautioned that how the experimental studies and findings are tied to

the ICME modeling efforts were not well defined in the presentation. Nevertheless, this reviewer trusts that the modeling and experiments will support each other to yield verified models that give insights into the processing recipes.

Reviewer 3:
The reviewer commented that the technical accomplishments are not clearly correlated to the 3GAHSS mission.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said there is strong collaboration among the three groups to keep moving forward.

Reviewer 2:
The reviewer replied there is good collaboration with a well-defined team.

Reviewer 3:
The reviewer stated there is a good mix of national laboratories and academia, but added the project would benefit from more industrial (OEM and supplier (steel company) 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 stated that there are great opportunities to expand this work and is recommending that DOE direct fund similar work in the future at Colorado School of Mines (CSM).

Reviewer 2:
The reviewer agreed that the proposed work addresses the remaining challenges. However, the reviewer cautioned that the ties from experiments to the ICME models that will direct processing are not clear from the presentation.

Reviewer 3:
The reviewer stated that future research is not clearly defined.

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

Reviewer 1:
The reviewer stated that UHSS will drive lightweight materials into vehicles cost effectively.

Reviewer 2:
The reviewer remarked that improvements in steel are critical to reducing vehicle mass and thus displacing petroleum.

Reviewer 3:
The reviewer said that heat treatment of 3GAHSS is critical to the lightweighting fuel reduction initiative

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

Reviewer 1:

The reviewer agreed that there are sufficient resources for this project.

Reviewer 2:

The reviewer said this project is appropriately funded.

Reviewer 3:

The reviewer concluded that the mission is not defined well enough to justify additional resources.

Presentation Number: lm108
Presentation Title: Development of Low-Cost, High-Strength Automotive Aluminum Sheet
Principal Investigator: Russell Long (Arconic)

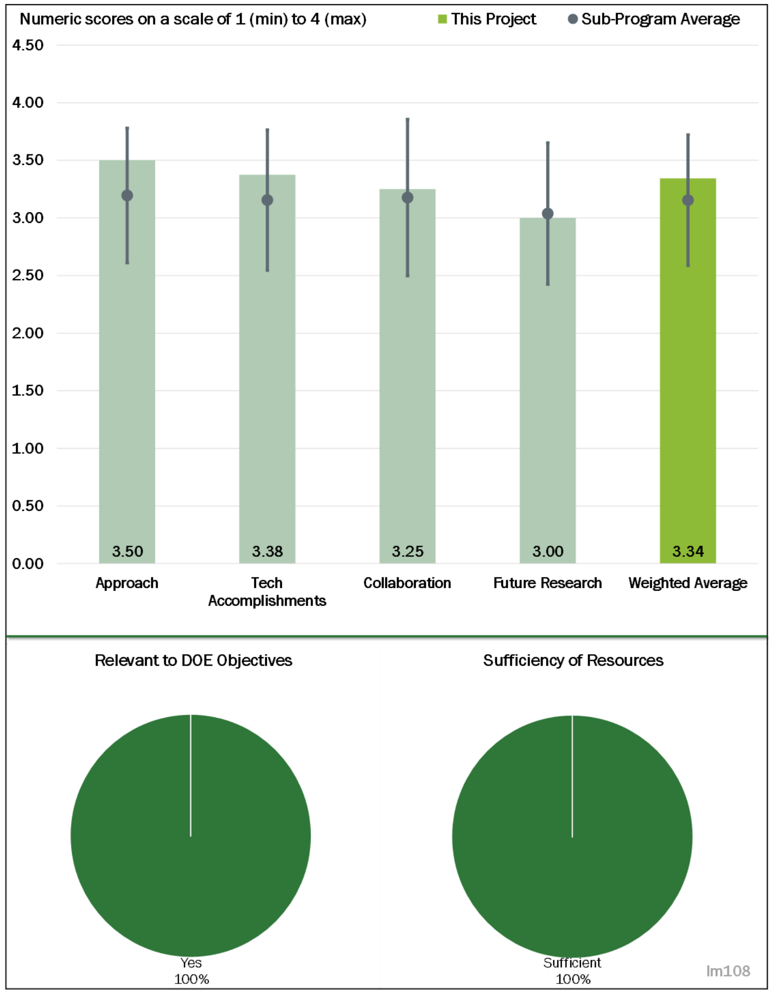

Figure 7-13 - Presentation Number: lm108 Presentation Title: Development of Low-Cost, High-Strength Automotive Aluminum Sheet Principal Investigator: Russell Long (Arconic)

Presenter
Russell Long, Arconic

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

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 affirmed there is a well-fined, calculated approach towards the development of a cost effective high-strength Al alloy.

Reviewer 2:
The reviewer agreed that the approach is well considered and appropriate for this project and that the efforts address the critical project areas, adding that the continuous casting for the prototype alloy demonstrates the potential for this improved technology.

Reviewer 3:
The reviewer stated that the approach detailed in the presentation is adequate to achieve the goals of demonstrating viable warm forming of a car part with a high-strength Al alloy while achieving cost reductions of $2/lb.

Reviewer 4:
The reviewer cautioned that FSW is going to be an expensive approach to joining and asked if the team has completely given up on fusion welding, e.g. spot welding, and if so, why. The reviewer wondered if the material can be engineered to improve spot weldability without loss of properties. The reviewer also noted that there is no information that would provide reassurance that the initial 2.5-mm gauge is suitable for the load cases to which the door ring must be evaluated. The reviewer asked what if the team has to upgauge to 3.0-mm to meet side impact requirements. The reviewer also observed that Slide 12 contains no label(s) on color contour keys and asked what is being shown in the corresponding contour plots. The reviewer also noted that the figure at the lower right needs a length scale and that the flow curves in Slide 12 suggest a loss of properties in the FSW. The reviewer asked why is this so and, how will this be incorporated into a model of the part when in the vehicle side-body structure.

The reviewer also remarked that the heat-affected zone (HAZ) seems too narrow for extraction of a miniature tensile specimen and asked how the flow curve corresponded to the HAZ in the flow curve plot in Slide 12 generated. The reviewer next noted that on Slide 24 to please include the baseline steel currently in use for the door ring in the strength-ductility (“banana”) chart wondered if the baseline steel is a press hardening steel (PHS). Finally, the reviewer commented that for Slide 9, when are the data available, it would be helpful to show how corrosion changes with heat treatment and corresponding mechanical properties.

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 praised as impressive the progress on testing and evaluations of the alloys, adding that the project is close to done and last year’s efforts indicate success. The reviewer elaborated that forming trials show the formability of this 7xxx Al at the 225 Celsius (°C) and that the interactions of the forming temperature and the final strength show the sensitivity of the strength on the process interactions. The reviewer remarked that the 520 to 580 Mega-Pascals are below target but are still a substantial improvement over 5xxx and 6xxx alloys.

Reviewer 2:

The reviewer noted that there have been results in two major areas (tailored-welded blanks [TWB] development and forming trials) and added that the workers seem to be on course to achieve their goals.

Reviewer 3:

The reviewer stated that progress appears to be following the schedule of the project.

Reviewer 4:

The reviewer said there has been excellent progress and accomplishment relative to weight goal. However, the reviewer added there was no mention as to $2/lb. saved cost goal or cost model, but that this must be enforced as a go/no-go milestone to continue to budget period two. The reviewer also commented that there is no mention of stress corrosion cracking (SCC) and highly recommended a SCC test be conducted and reported.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer agreed that there is clear evidence of close cooperation between Arconic (formerly Alcoa), Magna Cosma, Honda, and ORNL and added that the project seems to be very nicely integrated with a good sharing of the workload all aimed at meeting the project deliverables.

Reviewer 2:

The reviewer affirmed there is strong collaboration on the alloys and processing and that the last stage will address the final testing. The reviewer also added that working with ORNL and TWB Co. as the TWB supplier are strong additions.

Reviewer 3:

The reviewer stated there is a strong team that includes Honda, Magna and ORNL, and that work appears to be well coordinated and the contributions by each partner fairly balanced.

Reviewer 4:

The reviewer stated there is a great project team comprised of material supplier, OEM, tier 1 (supplier), and a DOE national laboratory.

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 agreed that the proposed future research is very good to result in a TWB bodyside type component and noted that the plan includes "evaluation" of part. However, the reviewer would like the recipient to define actual tests associated with "evaluation" and $2/lb. saved cost model.

Reviewer 2:

The reviewer stated that the proposed future work is consistent with the goals that need to be achieved but that there are some areas that need to be addressed that are not specifically mentioned in the future work to include running rate simulations, paying particular attention to temperature and throughput. The reviewer inquired about whether a high enough production rate can be sustained to make it economically viable, given all the warm press process sensitivities. The reviewer also commented that strain maps for the pressed parts would be prudent to help optimize the process, adding that this goes to address balancing strength, elongation, and degradation resistance whether by corrosion or other type of cracking.

Reviewer 3:

While the future work address most of the remaining barriers and challenges, this reviewer wanted to see something explicit about characterizing how the processing parameters influenced spring-back.

Reviewer 4:

The reviewer stated that the work needs to include the development of at least one FLD at the preferred warm stamping temperature, probably with something like the Nakajima technique appropriately corrected. The reviewer also stated that the cost-impact of cleaning warm stamped parts with wax-based lubricant needs some attention and asked what role (if any) do stamping speeds (strain rates) impact formability and asked if the warm stamping speed can be increased. The reviewer pointed out that Slide 17 suggests no future work involves the development of material constitutive models for finite element simulations of both the warm stamping process and formed component performance in a vehicle. The reviewer remarked that this is something that Honda should be able to help with and recommended that Arconic consult with Honda and perhaps Magna on these issues (especially as Slide 15 indicates Magna is to help). The reviewer also explained that the literature on low-dynamic testing of 7XXX alloys within nominal strain rate range of 10 -500/s is controversial and asked how is the project going to evaluate the high strain rate performance of the warm-stamped 7055 to provide reassurance that strain rate dependence of the flow properties is not of concern. The reviewer noted that a 2.5-mm initial gauge has been chosen and wondered if the project team needs to upgauge, where is the crossover point at which 7055 Al becomes impractical and the team is right back to PHS for the door ring part. The reviewer concluded that the consideration of the alloy-dependence of the fractures/failures seen at the lower warm stamping temperatures (on Slide 10) needs attention and asked if there are specific microstructural mechanisms that require greater control at the lower warm stamping temperatures.

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

Reviewer 1:

The reviewer stated that warm formed 7000 Al at $2/lb. saved provides significant opportunity to reduce vehicle mass which will result in in fuel reduction and environmental benefit.

Reviewer 2:

The reviewer remarked that high strength Al is critical to reducing mass and thus displacing petroleum.

Reviewer 3:
The reviewer agreed that vehicle mass reduction through judicious selection of component materials supports DOE objectives and added that in this case, warm stamped 7055 Al has a density that is less than PHS.

Reviewer 4:
The reviewer said that it demonstrates the viable use of a high-strength Al alloy that can assist in significantly reducing the weight of a vehicle and improve fuel efficiency.

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

Reviewer 1:
The reviewer praised the great mix of OEM, Tier 1 and Tier 2 suppliers, and DOE national laboratory resources.

Reviewer 2:
The reviewer said there are sufficient resources to complete the project.

Reviewer 3:
The reviewer stated the resources appear to be sufficient.

Reviewer 4:
The reviewer remarked that without having access to financial data and the statement of work (e.g., hours needed to accomplish tasks, charge rates, and materials cost), it is difficult to make this assessment accurately and added that there is also no matrix/presentation of data on money spent versus work done to assist.

Presentation Number: lm109
Presentation Title: High-Throughput Combinatorial Development of High-Entropy Alloys for Lightweight Structural Applications
Principal Investigator: Jeroen van Duren (Intermolecular)

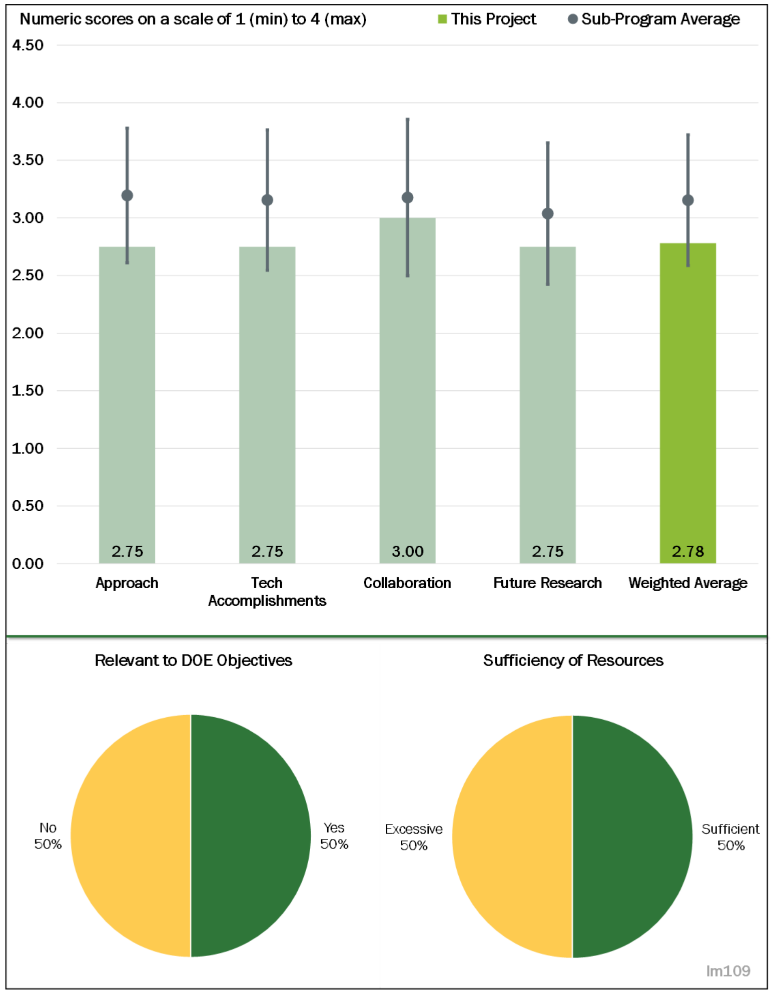

Figure 7-14 - Presentation Number: lm109 Presentation Title: High-Throughput Combinatorial Development of High-Entropy Alloys for Lightweight Structural Applications Principal Investigator: Jeroen van Duren (Intermolecular)

Presenter

Jeroen van Duren, Intermolecular

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 explained that the approach is to overcome technical barriers by demonstrating the viability of low-density, high-entropy alloys as a lightweighting approach for vehicle applications. The reviewer observed that these materials have potential for alloys with greater strength than traditional alloys and design flexibility to address corrosion and processing challenges. The reviewer elaborated that the project is well designed and considers all expects of development including efforts to investigate phase diagram modeling for candidate materials, high-throughput screening and optimization of alloy families, lab-scale bulk studies, single-element substitution studies, manufacturability, scale-up, and material validation. The reviewer concluded that this approach is feasible and should integrate well with other efforts for lightweight metals R&D.

Reviewer 2:

The reviewer commented that the approach is exciting to look at a large unexplored metallurgy space for new alloys and that the stretch objectives are impressive. However, the reviewer remarked that while the approach of combined computational and different experimental studies is interesting, for this investigation there needs to be more experimental effort.

Reviewer 3:

The reviewer stated that the overall approach adopted to perform the work is reasonable, adding that the work is complicated and other ways to do it can always be suggested/found. The reviewer explained that the rating is an acknowledgement of the degree of difficulty rather than a criticism of the approach and that successful completion of all the task laid out will lead to useful results. The reviewer then listed a few concerns.

Regarding the use of thin film to measure some materials properties, materials properties such as hardness from thin films are difficult to correlate to those of bulk properties. For one, thin films do not provide constraints to instruments like indenters like bulk specimens do. Care must therefore be exercised as far as the measurements and the use of the data is concerned.

The validation and acceptance criteria used to screen experimental data (from the databases used during the phenomenological alloy design step) for quality and pedigree, a more robust protocol is required to forestall the use of bad data in simulations and model development.

Finally, only one alloy met desired targets after screening 150 billion possibilities. The reviewer pointed out that this is a risk to success because if this alloy fails to meet all criteria, what is that alternate approach?

Reviewer 4:

The reviewer noted that this project is aimed to study high-entropy alloys with high strength and low cost and that the presentation claims that one alloy was chosen from 150 billion possible combinations. The reviewer suggested it would have been better to have selected a group or family of materials. The reviewer also cautioned that relying on reported results without cross-checking the validity seems to be not prudent and added that while the difficulties of using models in alloy selection is understood by the project team, solutions have not been provided or sought. Finally, noting that the approach has been stopped and an alloy system randomly chosen to evaluate the performance, the reviewer asked what was the rational for the alloy selection.

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 that the phase diagram work appears to be on track for success and offered that the improvements to the literature data are worth the cost of this project on its own. The reviewer praised this as nice work. The machine learning to find potential alloys uses methods that this reviewer has not seen before. The reviewer wished the team good luck for the rest of the project.

Reviewer 2:

The reviewer stated that significant progress and technical accomplishments have been made with data collection and analysis of a multitude of compounds but that the usefulness of the models used for a wide range of alloys outside of the current high-entropy alloys database requires validation to move forward with optimization and single-element substitution studies. Although performance indicators (milestones) have been met, the reviewer cautioned that the progress in meeting the DOE goals for production materials has yet to be demonstrated and has significant technical and cost challenges that are high risk.

Reviewer 3:

The reviewer commented that the work, in the current format, may not achieve the intended goal and added that the team accepts this conclusion and is trying to seek the best possible system under the current circumstances. The reviewer remarked that development of the modeling procedure to downselect alloy systems is good but could be improved to make the process robust. However, the reviewer cautioned that validating the process need to be done, adding that a reverse engineering approach could be used to validate the current alloy selection process.

Reviewer 4:

The reviewer replied that technical accomplishments are promising but added that a lot of work still has be carried out. The reviewer directed the reader to the future work section for additional comments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the clear roles and responsibilities of each team member have added to the success achieved so far and that the team is using the best of each contributor.

Reviewer 2:

The reviewer noted that project collaboration involves a research company, two universities, a tier 1 supplier, and an automobile manufacturer and that the work done to date has been primarily in data analysis and early stage material development. The reviewer also noted that the equipment manufacturer has only been involved as an advisor and there is no indication in the presentation that a high-entropy alloy will be accepted and transitioned to the manufacturer.

Reviewer 3:

The reviewer commented that the bulk of the modeling work seems to have been carried out by one entity. Observed that this work is modeling intensive, the reviewer stated that one wonders if any improvements can be made in the division of labor but regardless, there are clearly defined roles within the collaborative group.

Reviewer 4:

The reviewer said that the project is more fundamental work and the involvement of universities is quite understandable. However, the reviewer also commented that the role of the automotive OEM is not quite explained other than in the technical specification, but that this was already set by DOE even before the proposal submission.

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 stated that the proposed future work to complete the project appears to address the key open issues for the last six months of the project.

Reviewer 2:

The reviewer agreed that the proposed future research is good but added that it must ensure a robust model validation is carried out after model development is complete, noting that many models fall short when used to predict behavior or outcomes for datasets or specific conditions not used in their development. The reviewer added that a clear and technically sound protocol for model validation needs to be developed.

Reviewer 3:

The reviewer commented that the project has demonstrated a well-planned and logical approach to performing data analysis and material property characterization but that the challenges and barriers have not been resolved. The reviewer also remarked that the future work presented to explore more novel microstructure for low-density, high-entropy alloys (a reversal from high-density high-entropy alloys) and focus less on face center cubic and body center cubic 4/5-element designs seems to mark a total change in direction that has high risks as an alternate development pathway. The reviewer added that future efforts to populate and experimentally validate these alloys in the current database would be worthwhile if there is a material that successfully meets DOE goals developed in conjunction with the database.

Reviewer 4:

The reviewer stated that given the inability of current databases and published literature to develop models for alloy selection, more effort needs to be focused on these areas and remarked that developing randomly chosen alloys is not a useful process as it will only provide random datasets.

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

Reviewer 1:
The reviewer stated that this is a great example of a project to look "outside the box" for lightweight materials for automotive applications.

Reviewer 2:
If the work is successful, the reviewer commented, the approach and models developed will be a powerful tool(s) for the development of lightweight alloys that would impact fuel efficiency in vehicles.

Reviewer 3:
The reviewer reflected that this is a long-range project and the fuel savings may not be immediate.

Reviewer 4:
The reviewer replied no, elaborating that although the stated barriers and objectives of this project addresses the overall DOE objectives of petroleum displacement by fuel efficiency of lightweight vehicles, there has been no result or product from this project that can meet the DOE objectives. The reviewer clarified that while there is a lot of good materials science in this project, it lacks a technology that will solve the problem of developing a lightweight material to replace currently used lightweight materials in the automotive industry.

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

Reviewer 1:
The reviewer replied that sufficient resources are available to complete the project.

Reviewer 2:
The reviewer remarked that without having access to financial data and the statement of work (e.g., hours needed to accomplish tasks, charge rates, and materials cost), it is difficult to make this assessment accurately and added that there is also no matrix/presentation of data on money spent versus work done to assist.

Reviewer 3:
The reviewer commented that the work plan does not seem to justify the high cost of the proposal.

Reviewer 4:
The reviewer observed that for a $3 million investment with high DOE cost share over 3-year period and milestones that are primarily studies, the costs seem to be rather high for the results produced which are primarily academic research that has no near- or mid-term solution to challenges identified by DOE.

Presentation Number: Im110
Presentation Title: *In-Situ* Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy
Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

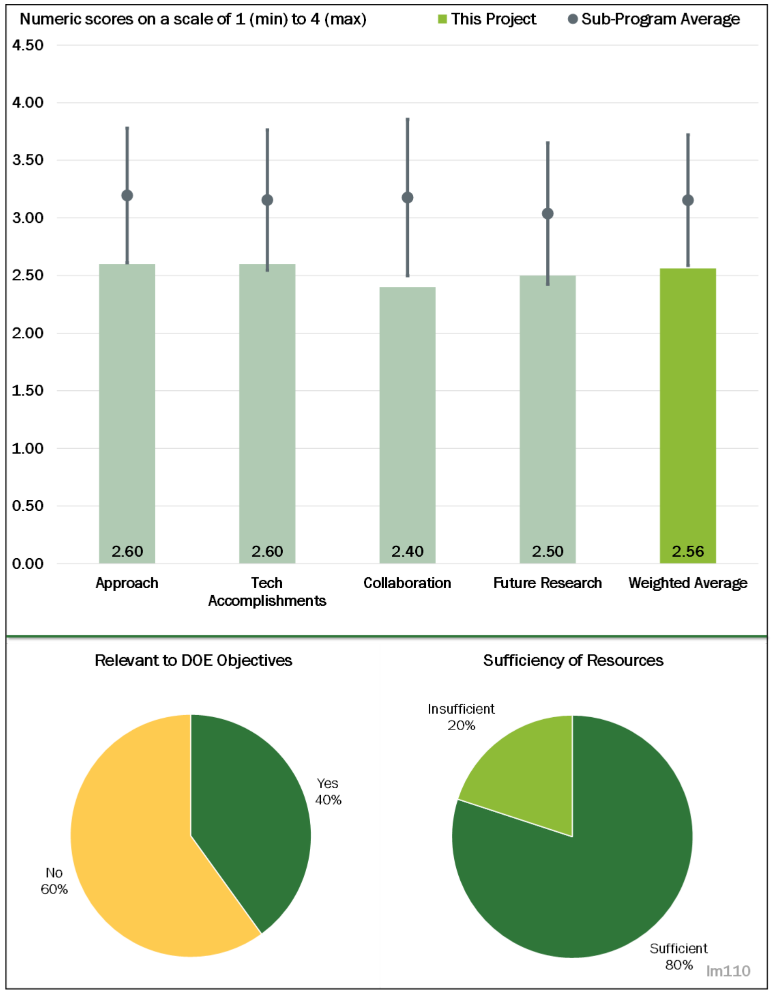

Figure 7-15 - Presentation Number: Im110 Presentation Title: *In-Situ* Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Presenter

Aashish Rohatgi, 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 the project is interesting but it does not directionally further the development of Mg alloys by solving two fundamental issues (corrosion and ductility).

Reviewer 2:

The reviewer commented that the overall approach adopted to perform this work is reasonable, adding that the work is complicated and other ways can always be suggested or found. The reviewer rating is an acknowledgement of the degree of difficulty of the work rather than a criticism of the approach. The reviewer expressed some concerns. Firstly, the use of deposited thin films for this work since deposited thin films do not usually mimic bulk materials properties and so correlation of results from thin films (to bulk material properties) might therefore be difficult. Secondly, this reviewer noted a lack of temperature measurement data, which means cooling rate assessments will be affected.

Reviewer 3:

This reviewer noted that this project was redirected late in the performance period to do atomistic modeling to provide adequate predictive tools that will enable the low-cost manufacturing of lightweight structures. The reviewer pointed out that the challenge is to provide data on the microstructural evolution during solidification at high cooling rates which is not available to validate existing models. While agreeing that the approach presented to achieving project objectives is well-designed and feasible if the instrument challenge to studying the cooling rates can be overcome, the reviewer cautioned that if this challenge cannot be overcome, then there will remain an inability to measure rapidly changing temperatures of the material sample.

Reviewer 4:
The reviewer stated that the approach of mixed experimental and modeling to understand the solidification is reasonable but added that the potential tools to be developed are only of marginal value to the automotive lightweighting community.

Reviewer 5:
The reviewer asked how the atomistic calculations are connected with the experiments in this project. The reviewer commented that the dynamic transmission electron microscope (DTEM) experiment looks really interesting but will apparently not be available for this project and asked how ESI uses the atomistic simulation results. The reviewer further remarked that it is debatable as to whether the atomistic simulations are really modeling microstructural evolution. While this reviewer appreciates the complexities associated with kinetics modeling, how was microstructure accounted for above the realm of a few hundred, thousand, or tens-of-thousands of atoms regime. The reviewer also asked how the atomistic simulations are connected with the cellular automata mentioned on Slide 8. The reviewer is struggling to understand how all of the pieces of this project fit together to meet the DOE-required deliverables. The reviewer asked what is being done with all of the data (experimental and computational) generated in this project.

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 agreed that the project deliverables were met so the accomplishments are good, adding that the shift due to the equipment delays was reasonably good. The reviewer remarked that the technique desired for the project was great for in-situ solidification and the current period accomplishments that are on atomistic modeling also helps inform the solidification in high-pressure die cast (HPDC) Mg. The reviewer characterized this as a good recovery.

Reviewer 2:
The reviewer stated that *in situ* solidification modeling is an interesting topic and the atomistic modeling could help, but only if directed at solving the key issues with Mg, namely, corrosion and ductility.

Reviewer 3:
The reviewer responded that the major technical accomplishment is the development of the Atomistic-Kinetic Simulations of Microstructural Evolution self-learning simulation tool while others accomplishments include the study of Al and Mg vacancy exchange and how Al diffuses through Mg. However, the reviewer is finding it difficult to assess the impact of these findings on how they will directly affect the cost of Mg and its wider use in the automotive industry.

Reviewer 4:
The reviewer observed that the technical accomplishments presented were scientific only and focused on the effects of vacancies that affect atomistic diffusion in Mg. Furthermore, the only accomplishments presented were ProCAST calibration parameters for secondary dendrite arm spacing; grain-size in AZ91 was determined; and a methodology was developed that can be applied broadly to hexagonal close packed systems for more rigorous and accurate calculation of solute diffusivity. The reviewer pointed out that these are academic and do not demonstrate progress toward directly meeting any DOE goals and surmised that this might be due to the fact that the project was redirected late in the schedule.

Reviewer 5:
Without experimental data for comparison, the reviewer found it difficult to judge how accurate the computational results are and added that development of the DTEM would really have helped this project. The reviewer concluded that the project seems to be struggling somewhat.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that collaboration with ESI appears to have been successful and that the efforts on the thermal modeling and ProCAST looks reasonable. The reviewer added that the small project team limited collaboration but eased project planning.

Reviewer 2:
The reviewer noted that there was only one company presented for collaboration and that appears to be a subcontractor who was funded to do modeling studies.

Reviewer 3:
The reviewer remarked that an industrial partner, a supplier, or OEM, could provide technical input and direction to the team and set it on a path of relevance

Reviewer 4:
The reviewer replied that it is not clear what specifically ESI is doing or how PNNL work is coupled with the ESI work. For example, the reviewer asked if these are two separate projects altogether.

Reviewer 5:
The reviewer observed that there is only one partner in this work and that partner is a sub-contractor, but added that it is clear this partner contributed to the modeling effort. However, the reviewer stated it is difficult to gauge how much work was carried out by PNNL and how much was carried out by ESI.

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 replied that since little time is left, future work should address the remaining deliverables.

Reviewer 2:
The reviewer remarked that atomistic modeling is a good field and suggested a concentration on basal plane pinning as a mechanism to improve shear strength and ductility.

Reviewer 3:
The reviewer stated that there is no proposed technical work except for preparing a manuscript, presumably for publication. At a minimum, this reviewer would have liked to have seen some model validation work with data not collected from this work.

Reviewer 4:
Other than publishing a paper, the reviewer asked what is to be done with the data to suggest (for example) new alloys and who is going to use the data to make a new material that is better than the existing casting materials. The reviewer said it is not clear if there will be any substantive legacy to this project.

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

Reviewer 1:
The reviewer replied yes.

Reviewer 2:
The reviewer said that Mg and Mg alloys still have the potential to deliver weight savings.

Reviewer 3:
The reviewer stated that while Mg is one of the lightweight alloys available for lightweighting automotive structures, this project only marginally helps with Mg casting. The reviewer noted that the limited use of Mg in autos is not directly dependent on the casting models and that corrosion and joining are much larger hurdles limiting the use of Mg.

Reviewer 4:
The reviewer remarked that this project was a study of atomistic effects and modeling of in-situ melting and solidification of Mg and so there is no direct relationship to DOE objectives for petroleum displacement.

Reviewer 5:
The reviewer is not clear about how the model developed will improve the price of Mg/Mg alloys for automotive use. From a technical point of view, the reviewer elaborated, it is unclear how the solidification and diffusion data, as well as the predictive model derived from this work, will be favorably applied to solve solidification and diffusion issues in Mg and Mg Alloy processing, and how that will impact processing/price of the material. The reviewer added that how these tools predict microstructure accurately is also not clear from the presentation. The reviewer also cautioned that the way the results are presented does not lend itself to an easy understanding of the extent to which the current work has contributed to the closure of this knowledge gap, adding that no inferences are drawn between the current results and how much the knowledge gained improves our understanding about how to solve the challenges identified. The reviewer said it is therefore difficult to gauge how far along the work moves us to the solution of the challenge(s) and wondered how these data would be used by sheet metal or die casting manufacturers to solve the challenge, and would these data result in the cost saving sought. The answers to these questions are conspicuously missing, the reviewer concluded but added that perhaps all these will be clear in the paper.

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

Reviewer 1:
The reviewer replied that the amount of funding is adequate for the amount of research performed over a four-year period.

Reviewer 2:
The reviewer stated that the resources are sufficient to complete this project.

Reviewer 3:
The reviewer commented that the project is 90% complete and there is no reason to believe funds will be insufficient to write a paper. The reviewer added that there are no data on remaining funds, so it is impossible to judge whether the remaining funds, if any, are excessive.

Reviewer 4:
The reviewer remarked that it seems that this project is suffering a bit from the resource standpoint and that it is unclear what ESI is doing and how the work is coupled with PNNL. The reviewer wondered whether additional resources would have helped solve the problems with the DTEM.

Reviewer 5:
This reviewer would not fund this area beyond the conclusion of the project.

Presentation Number: lm111
Presentation Title: Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys
Principal Investigator: John Allison (University of Michigan)

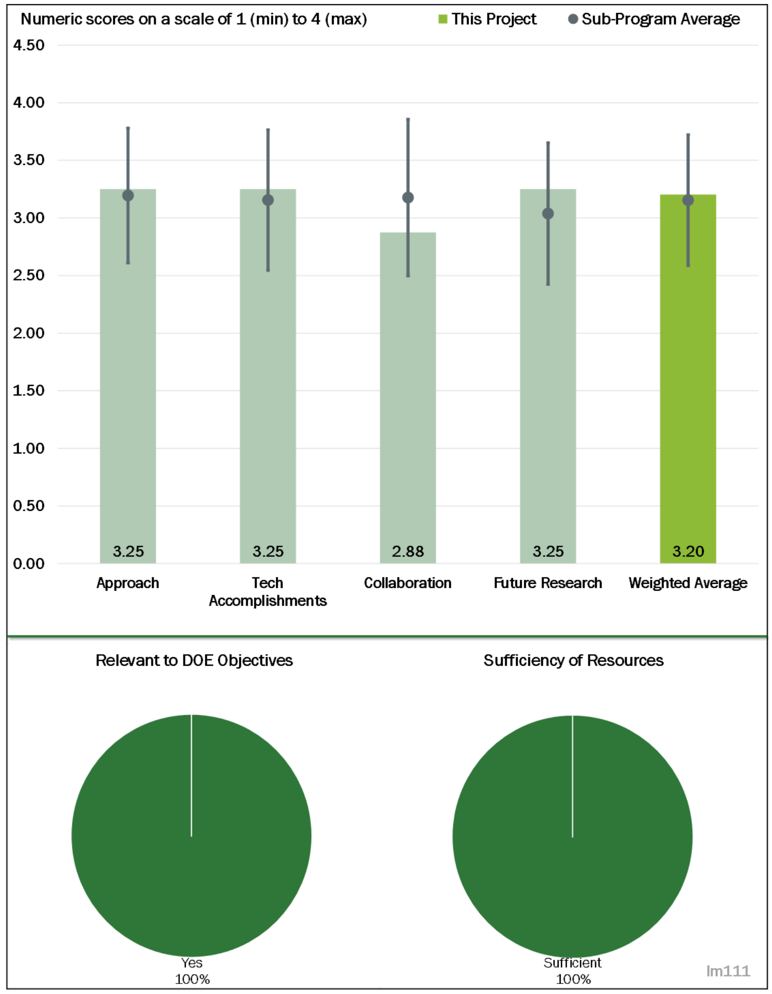

Figure 7-16 - Presentation Number: lm111 Presentation Title: Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys Principal Investigator: John Allison (University of Michigan)

Presenter
John Allison, University of Michigan

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 praised the solid approach to an essential problem (understanding phase transformation and segregation behavior during solidification) in advancing development and processing of Mg alloys. The reviewer had no real concerns and saw no obvious weaknesses within the context of the objectives and funding levels.

Reviewer 2:
The reviewer remarked that the approach as detailed on Slide 5 is comprehensive and covers key topics/tasks that will lead to the required deliverables and that providing the missing data in the plot at the upper right of Slide 8 is a very valuable contribution. The reviewer also stated that the ICME approach of Slide 18 is sound and certainly very interesting. One question the reviewer had pertains to whether or not the ICME approach can lead to a new cast alloy with improved properties once the database has been suitably populated. Otherwise, the reviewer asked if the ICME approach will always depend upon an existing material.

Reviewer 3:
The reviewer stated that the overall approach adopted to perform this work is reasonable, adding that the work is complicated and other ways can always be suggested or found. The reviewer’s rating is an acknowledgement of the degree of difficulty of the work rather than a criticism of the approach.

Reviewer 4:
The reviewer observed that the micro and macro segregation in Mg castings was estimated and measured and remarked that the impact of rapid solidification during die casting is a serious problem and the segregation is not fully explained. The reviewer added that this work is planned well with experiments complementing the modeling and thermodynamic calculations.

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 praised the excellent progress with many interesting and useful results. The only lingering question the reviewer had is how others will use the data (or if they will use the data) to improve existing casting processes.

Reviewer 2:
The reviewer remarked that the technical progress made includes HPDC simulation, phase quantification, and certain materials characterization including grain distribution and electron probe micro-analyzer (EPMA) analysis of micro-segregation. However, the reviewer further remarked that a bit of work needs to be done to conclude the project including completing the micro-segregation and phase transformation characterization and development of the models to predict microstructural evolution during heat treatment. The reviewer added that these are very important aspects of the work, without which value would not be realized.

Reviewer 3:
The reviewer stated that making such a dataset publicly available is extremely valuable to elevating the future development of improved Mg alloys. The reviewer elaborated that trends in many of the micro-segregation results (such as location dependent segregation) are anticipated from general solidification theory, but the quantification and modeling of such effects for this class of alloys is of great value and will accelerate future development. Having partition coefficients defined and models validated via EPMA analysis is particularly valuable, the reviewer added, as is definition of the limits of the Scheil approach during rapid solidification. However, the reviewer remarked that it was somewhat disappointing to see that there were no remaining challenges and barriers (one always hopes that the work is difficult or novel enough that such issues are always present) with 18 months remaining in the project, but the experience and skill of the PI and the limited scope of the effort make this almost understandable.

Reviewer 4:
There reviewer commented that there are many obstacles to the process of alloy optimization for Mg die casting alloys, adding that one of the is the segregation of alloying elements during the rapid cooling and noted that effect of heat treatment on the composition is less understood. The reviewer observed that this work is trying to solve these particular problems encountered during solidification. The reviewer also observed that there are other issues encountered during fluid flow and pressurization contributes to the complex issue but were not evaluated as part of the work. The reviewer cited as an example the formation of externally solidified crystals, which is controlled by the temperatures, alloy composition, and flow time which, in turn, affect the final segregation pattern and said that this may need to be evaluated in the future.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer responded that close collaboration between Ford and the University of Michigan is evident.

Reviewer 2:
The reviewer commented that only one industrial partner involved is in this project but that the level of cooperation is significant with the industrial partner making castings and providing commercial software for the work.

Reviewer 3:
The reviewer stated that this work is being carried out in partnership with Ford Motor Company, which provided the super vacuum die casting plate casting. The reviewer added that most of the modeling work seems to have been carried out at the University of Michigan.

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 agreed that the proposed future work to complete this effort and transfer the knowledge to the research community through the National Institute of Standards and Technology is high value and a good investment by DOE.

Reviewer 2:
The reviewer stated that the proposed future research appears to be relevant to the project deliverables.

Reviewer 3:
The reviewer replied that the work being proposed, if successfully completed, will yield useful results. However, the reviewer would like to see model validation included in the future work and the model should be validated with data not used to develop the model in order to ensure the model will not breakdown when used to predict results from other tests or other datasets. The reviewer elaborated that at present, cooling rate measurements are not possible but instead predicted. The reviewer would like to see a better grasp on how to more accurately determine/control the cooling rates. Right now, they are predicted to be between 100 and 300ºC/s.

Reviewer 4:
The reviewer stated that the last year of the work is trying resolve some of the unanswered questions, as well as ensure effective knowledge transfer.

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

Reviewer 1:
The reviewer replied that increased lightweighting, via increased, effective use of Mg, will accelerate petroleum displacement and that the type of work being conducted in this study is foundational to enabling the industrial materials community to advance design and manufacturing of Mg alloys.

Reviewer 2:
The reviewer responded that Mg can contribute to the weight saving of vehicles and added that it is known that lightweighting reduces fuel consumption and greenhouse gas (GHG) emissions. In case electric vehicles, the reviewer concluded, lightweighting can improve the range of operation.

Reviewer 3:
The reviewer replied yes.

Reviewer 4:
The reviewer agreed but said that the way the results are presented does not lend itself to an easy understanding of the extent to which the current work has contributed to the closure of this knowledge gap. In addition, the reviewer said no inferences are drawn between the current results and how much the knowledge gained improves our understanding about how to solve the challenges identified. The reviewer said that it is therefore difficult to gauge how far along the work moves us to the solution of the challenge(s) and asked how would these data be used by sheet metal or die casting manufacturers to solve the challenge, and would these data result in the cost saving sought. The reviewer said that the answers to these questions are conspicuously missing.

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

Reviewer 1:
The reviewer responded that the resources are sufficient.

Reviewer 2:
The reviewer replied that there is $132,000 in FY 2017 (which ends Sept, 30, 2017), but there appears to be no funding at all for FY 2018 (October 1, 2017 to September 30, 2018) yet the stated end of project is October 2018, which is FY 2019. The reviewer added that the work is 80% complete, but the lack of funding to FY 2018 is hard to understand unless a no cost extension has been granted.

Reviewer 3:
The reviewer had no comments.

Presentation Number: lm112
Presentation Title: Cost-Effective Magnesium Extrusion
Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

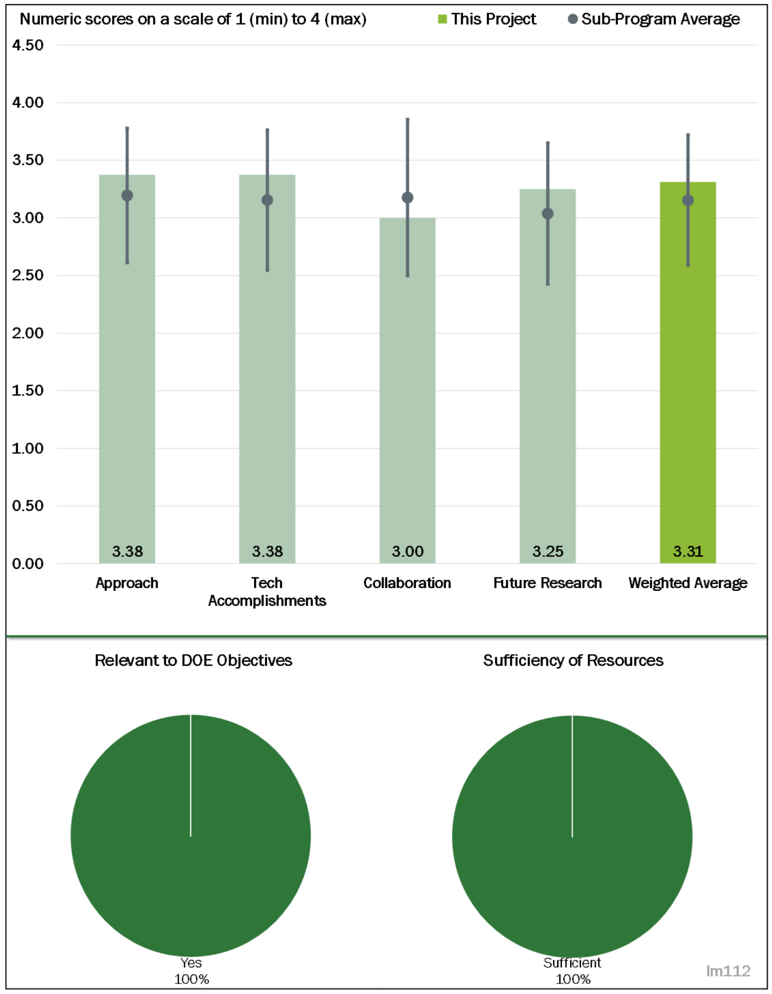

Figure 7-17 - Presentation Number: lm112 Presentation Title: Cost-Effective Magnesium Extrusion Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Presenter
Vineet Joshi, Pacific Northwest National Laboratory

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

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

Reviewer 1:
The reviewer said the approach for this project addresses the technical barriers for use of Mg alloys in automotive applications limited by strength, ductility, and energy adsorption. The reviewer characterized the project as well-designed and one that will provide feasible results for first-order modeling and detailed thermal simulations; extrusion system development; materials characterization and model validation; scale-up of a mature extrusion process; design and integration of a bridge die for direct extrusion of a Mg alloy; and development of process parameters for Mg extrusion using the bridge die. The reviewer added that this approach integrates well with other efforts to increase lightweight metals such as Mg into automotive applications.

Reviewer 2:
The reviewer commented that this is an experiment-based project in which the back extrusion of Mg billet using the basic principle of FSW is being evaluated. The reviewer noted that the friction during the process increases the temperature, possibly to the semi-solid region, which makes the flow easier and reduces the force required. The reviewer concluded the experiment is planned and executed well.

Reviewer 3:
The reviewer stated that the approach is quite unique considering microstructure changes in Mg but would like to see if mechanical properties get affected due to the new extrusion process.

Reviewer 4:
The reviewer said there are not many applications for Mg tube extrusions, but if it is continuous and cost effective, a replacement for an instrument panel beam is possible.

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 replied that the technical accomplishments and progress for this project has demonstrated significant contribution to the DOE goals for using lightweight metals such as Mg in automobile components. The reviewer found that all performance indicators (milestones) were met with exception for one delay due to equipment procurement lead time. The reviewer praised the outstanding progress made in the use of shear-assisted processing and extrusion technology to manufacture Mg tubing that can be made in production quantities with up to 50% increase in elongation compared to conventional extrusion processes.

Reviewer 2:
The reviewer praised the approach as sound and well thought out, adding that it really looks like the team is operating in the SSF temperature range and thus the lower pressure and unique microstructure that does look promising.

Reviewer 3:
The reviewer commented that this is a patented process and the technical development in the year of review is the finding on the importance of flutes in the tool surface. The reviewer added that this geometry makes the process easier in certain cases although the reason for the process improvement is not fully explained yet. The reviewer concluded that use of alloys without rare earth (RE) elements is a good development as this reduces the dependency on foreign supply.

Reviewer 4:
The reviewer said that the accomplishments are quite reasonable.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer responded there was a good mix of national laboratory and industrial partners.

Reviewer 2:
The reviewer observed that project collaboration included a national laboratory and performing partners from a university, a tool fabricator, and a tier 1 supplier, adding that each provided a significant contribution to the project objectives. While no automobile manufacturers were involved as a direct collaborator, the reviewer noted the tier 1 supplier was in routine contact with manufacturers.

Reviewer 3:
The reviewer stated that the tier 1 supplier is involved by providing specifications and time for in-kind contribution while the academic partner is involved in characterization efforts. Basically, the reviewer said, this project is a development of PNNL, which applied for IP protection.

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 affirmed that the future efforts for completion of this project are effectively planned in a logical progression with appropriate decision points and considerations for overcoming potential barriers to transitioning the technology to industry. The reviewer added that risks are minimal based on progress to date and no alternative development pathway is needed. The reviewer explained that future efforts involve

production of several feet of tubing (pre-production levels) of Mg tubing; identification of the parameters for extruding Mg under steady-state conditions; extruding at rates relevant to industry; demonstration of system repeatability and robustness; and development of extrusion parameters to create desired grain size and texture to maintain physical properties. The reviewer remarked that all of these efforts are designed to transition the technology to industry.

Reviewer 2:
The reviewer agreed that proposed future research connects the ongoing work. The reviewer would be interested to see results next year.

Reviewer 3:
The reviewer observed that scaling up is the next phase and procurement of equipment is in the plan with installation and production of larger quantity of tubes the focus for next year.

Reviewer 4:
While seeing limited applicability, this reviewer replied yes to a recommendation for future funding in order to explore the R&D.

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

Reviewer 1:
This reviewer stated that the project is focused on producing Mg components using a novel extrusion process, and since Mg is a leading lightweight material used in automobile parts, this project definitely supports the DOE objectives to reduce U.S. dependency on petroleum through application of lightweight materials in automobile design.

Reviewer 2:
The reviewer observed that Mg can contribute to the weight saving of vehicles and added that it is known that lightweighting reduces fuel consumption and GHG emissions. In case electric vehicles, the reviewer stated that light weighting can improve the range of operation.

Reviewer 3:
The reviewer commented that while there is limited potential for Mg extruded tube, it would still deliver weight savings. The reviewer added that percent elongation looks promising.

Reviewer 4:
The reviewer was unsure of the most relevant application to displace petroleum.

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

Reviewer 1:
The reviewer agreed that funding of $1.2 million and personnel from four organizations involved in the execution of this project is sufficient to meet the project goals and DOE objectives to overcome the barriers and challenges for using Mg in automotive applications. The reviewer concluded that all milestones have been met to date with the exception of an equipment procurement delay and future milestones are on target.

Reviewer 2:
The reviewer answered that funding is appropriate.

Reviewer 3:
The reviewer had no comments.

Presentation Number: lm113
Presentation Title: Magnesium Corrosion Characterization and Prevention
Principal Investigator: Mike Brady (Oak Ridge National Laboratory)

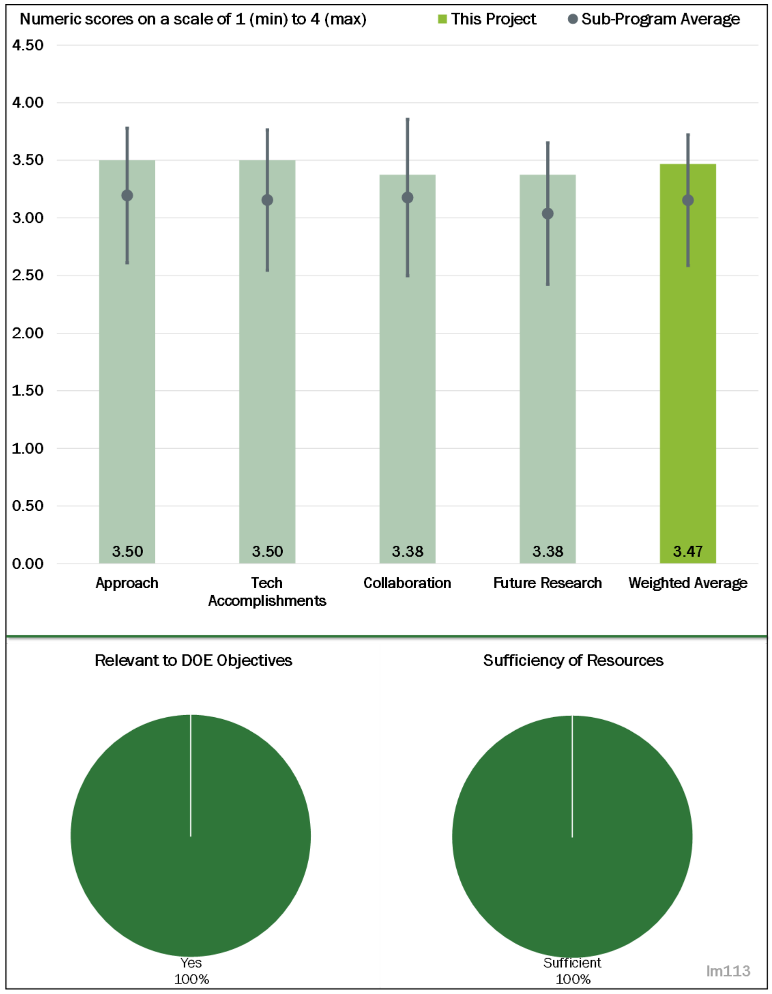

Figure 7-18 - Presentation Number: lm113 Presentation Title: Magnesium Corrosion Characterization and Prevention Principal Investigator: Mike Brady (Oak Ridge National Laboratory)

Presenter

Donovan Leonard, Oak Ridge National Laboratory

Reviewer Sample Size

A total of 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 explained that the project uses a four-pronged approach to study Mg corrosion phenomena to include assessing the impact of other metallics and secondary phases on aqueous corrosion/film formation and hydrogen and oxygen uptake; focus on two key phenomena of unexpected rapid hydrogen ingress into Mg alloys; and establishment of substrate alloying segregation tendencies on state-of-the-art electro-ceramic coatings. The reviewer commented that the experiments are well designed and the project has a feasible approach to completing investigations for Mg corrosion characterization that will provide corrosion-resistant Mg alloys that can be used in production, performance, maintenance, repair, and recycling of Mg components.

Reviewer 2:

The reviewer replied that it is very interesting to see the characterization techniques used in this manner and that the new techniques will help with future research into this area. The reviewer added that this is a great addition to the research community in overcoming Mg challenges.

Reviewer 3:

Thee reviewer observed that the role of hydrogen in the corrosion of Mg is investigated and commented the experimental plan is good and executed very well. Noting that the experiments were conducted for four hours, the reviewer said that longer exposures would have revealed more information.

Reviewer 4:

The reviewer replied that the project is using some state-of-the art experimental tools to explore corrosion in Mg and that the work is certainly sound and there are some interesting results coming out of the work with much data. In the end, however, the reviewer wondered how all of the great data coming out of this project are going to be used to design future Mg alloys that are more corrosion resistant.

The reviewer also asked why is there no substantive component of this project that delves to one extent or another into these questions. The reviewer further wondered what the reason is for the hydrogen/deuterium (H/D) ingress into alloys with zirconium (Zr). The reviewer urged that this be addressed as soon as possible, asking if this a fundamental property of the group-4 metals. The reviewer surmised that this is evidently it is not a function of grain size and wondered if this some type of precipitate Zn_2Zr_3-induced field that enhances diffusion (such as dislocations attracting solutes in Al-Mg alloys because of the enthalpy).

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 replied that good progress has been made in meeting the performance indicators (milestones) which are fundamental studies of Mg corrosion that has resulted in two technical papers over the past year. The reviewer agreed that significant technical accomplishments have been achieved in developing an understanding of Mg corrosion through application of multiple new characterization approaches; identifying rapid hydrogen uptake in Mg alloys after short-term aqueous exposure; discovering significant implications for SCC and fundamental corrosion mechanisms; and establishing the relation of corrosion to alloy composition and nanostructure to provide a basis for corrosion-resistant designs. The reviewer offered that all of these will contribute to the success of using Mg as a lightweight material in automobile components that will meet DOE goals for lightweight materials development. The reviewer added, though, that more research is needed in coating effects.

Reviewer 2:

The reviewer said that accomplishments with the various experimental approaches are very impressive. The reviewer would like to see how all of the data can be used to suggest improvements to Mg alloys designs for corrosion resistance and need to find out why the Zr-enhanced H/D ingress. The reviewer wondered if this also occurs with the relevant RE elements, e.g., cerium, neodymium, europium (Eu), erbium, etc.

Reviewer 3:

The reviewer stated that it was very interesting to see the results of the deuterium penetration study.

Reviewer 4:

The reviewer replied that the measurement of hydrogen in Mg using various techniques was useful and that efforts to crosscheck the results from one investigation using other techniques is commendable. The reviewer added that the role of Zr and other RE elements on hydrogen diffusion in Mg need to be examined further.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer described excellent international academic team investigating a fundamental work, adding that the team is good. The reviewer also said the role of industrial partners in supplying raw materials and coatings for the work is commendable. The reviewer said that the role of the auto tier 1 supplier is not well defined but shows its interest in the subject.

Reviewer 2:

The reviewer lightheartedly asked who is not involved with this project, noting that everything seems to be covered and everyone has their own expertise for every aspect of this project. The reviewer characterized the collaboration as very good.

Reviewer 3:

The reviewer affirmed that overall, collaboration is excellent within the performing organization, elaborating that since this project address fundamental research in Mg corrosion, the primary collaboration and coordination is with researchers within the performing organization with some outside collaboration involving four universities and two tier 1 suppliers of Mg and coating materials while a second tier 1 supplier is used for technical input. The reviewer noted that no equipment manufacturers are involved but this is not a major concern at this stage of the research.

Reviewer 4:

Noting that the collaborators are listed on Slide 19, this reviewer has the impression that the vast majority of the work is being done at ORNL and asked if this is in fact the case. The reviewer said it would have been helpful if throughout the presentation the various collaborators' contributions were called out instead only of listing them at the end (which, the reviewer noted, is required by DOE).

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 future efforts within the time remaining for this project involve primarily the continuation of studies on hydrogen uptake by Mg but that some work will begin on understanding coating effects on Mg substrates. The reviewer added that these efforts appear to be effectively planned in a logical manner with appropriate decision points in the project schedule. The reviewer identified no risks and concluded that no alternate development pathways are necessary for these studies beyond what is already planned.

Reviewer 2:

The reviewer said it will be interesting to see the results of the coatings and that the H/D uptake phenomena relative to film formation study will help researchers with the next level of needed research into this topic.

Reviewer 3:

The reviewer said that information on the role of coating to prevent hydrogen intake is necessary but the effect of hydrogen in the Mg need to be studied further. The reviewer remarked that while the statement that only four hours are necessary for hydrogen infusion into Mg sounds ominous, many Mg components are being used in real life and exposed to humidity and other sources of water. The corrosion of these components is not catastrophic, the reviewer stated, and the significance of this finding need to be explained more clearly.

Reviewer 4:

The reviewer remarked that the proposed future work is interesting, and asked what is to be done with all of the data, and who is going to steer the data to the appropriate groups focused on developing more corrosion-resistant Mg alloys. The reviewer concluded that it seems that there is a lot of great scientific work going on in this project but its applicability/relevance to commercial alloys is questionable.

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

Reviewer 1:

This reviewer agreed that the project supports the overall DOE objective of using lightweight materials such as Mg for reducing the weight of future automobiles and therefore reducing the U.S. dependency on petroleum. By solving the problems with Mg corrosion through a better understanding of corrosion phenomena, the reviewer elaborated, the automotive industry is more likely to consider Mg in future vehicle designs.

Reviewer 2:
The reviewer commented that understanding corrosion effects on Mg will accelerate its adoption into the automotive world and that once these effects are known, mitigation strategies can start to be developed.

Reviewer 3:
The reviewer said the role of Mg in reducing the weight of vehicles could be significant (more than 30%) and that weight reduction can help to reduce fuel consumption and GHG emissions while also helping to improve the range in electric vehicles.

Reviewer 4:
The reviewer replied yes, Mg is a light weight metallic material being looked at for vehicle mass 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 characterized resources, both experimental and personnel, as outstanding.

Reviewer 2:
The reviewer stated that every one of the collaborators is playing an important role in fulfilling the entire scope of this project and that everything is on track for completion as expected.

Reviewer 3:
The reviewer agreed that funding is sufficient to support the number of researchers involved in the project for the three-year performance period providing FY 2018 funds are available and that all future milestones are anticipated to be met if funded at the projected levels.

Reviewer 4:
The reviewer had no comments.

Presentation Number: lm114
Presentation Title: Friction Stir Scribe Joining of Carbon Fiber Reinforced Polymer to Aluminum
Principal Investigator: Blair Carlson (General Motors)

Presenter
Blair Carlson, General Motors

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

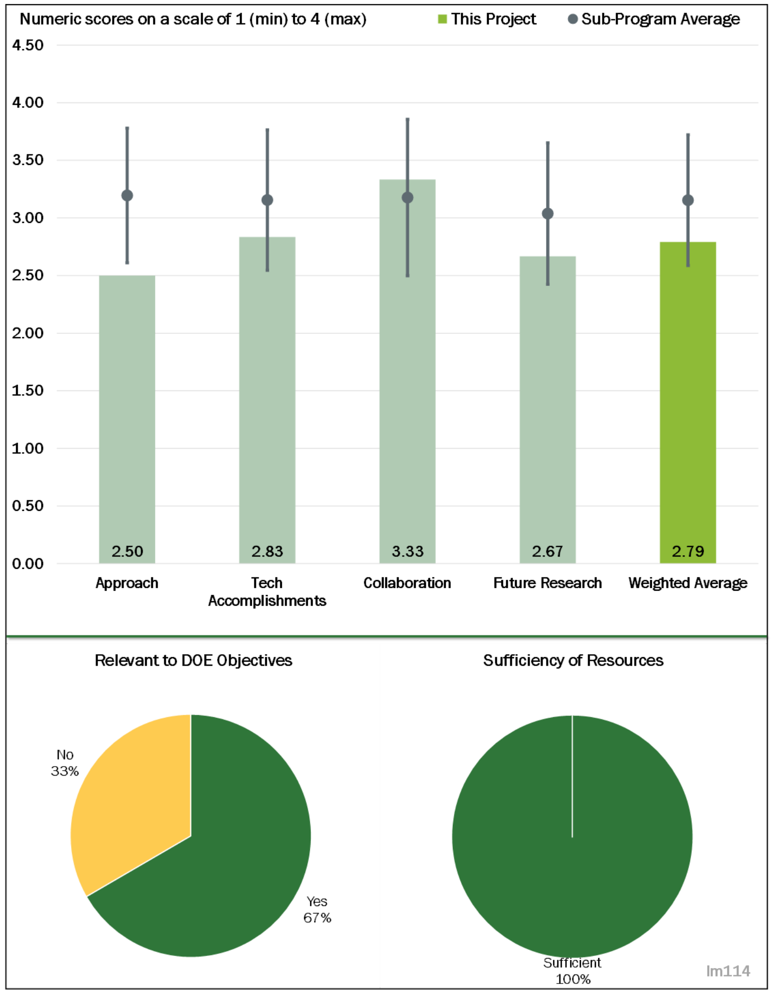

Figure 7-19 - Presentation Number: lm114 Presentation Title: Friction Stir Scribe Joining of Carbon Fiber Reinforced Polymer to Aluminum Principal Investigator: Blair Carlson (General Motors)

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 stated that the project seeks to develop joining technique for Al and CFRP using mechanical/metallurgical bonding, adding that the procedure is routine process development

Reviewer 2:
The reviewer identified the main weakness as the lack of sufficient go/no-go points, observing that the only go decision is based on strength while an important factor such as corrosion is omitted from the go/no-go decision.

Reviewer 3:
The reviewer said that joining CF composites to Al is technically very challenging and commented that the proposed research is high-risk.

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 praised the project as having made excellent progress in trying to make strong joints, but noted that the joint strength is still very low, indeed, considerably below the project target.

Reviewer 2:
The reviewer said that very good progress has been obtained on tool design and process optimization but the fact that corrosion has not been evaluated early in the project is a significant concern. The reviewer elaborated that if it were evaluated, the project could have identified this technical challenge early so that the materials design could have been optimized or planned for the future.

Reviewer 3:
The reviewer remarked that the finding of degradation of fibers after mechanical stirring is expected and the resultant loss in strength is predictable but this has not been foreseen by the project team nor was it modeled. The reviewer added that no other significant findings are reported.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised the outstanding collaboration with suppliers and universities, as well as the very efficient team work.

Reviewer 2:
The reviewer stated that all partners seem to be contributing.

Reviewer 3:
The reviewer remarked that the team has good integration and the tasks are well defined. The reviewer also noted that other similar projects are ongoing with the team members making this a subset of those 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 replied that reversing the joining sequence (from Al to composite) should be systematically tried as this potentially can be a good solution.

Reviewer 2:
The reviewer said it should be underlined that by not having identified the issue of corrosion early on in the project, the future work does not have an effective solution to this problem. The reviewer added that with a major materials problem at hand, some of the prototyping activities can be in vain.

Reviewer 3:
The reviewer commented that the joints did not meet the property requirements in the first phase and that this is due to the fact that one of the materials in the joint degraded during thermo-mechanical processing. The reviewer warned that this will be the result of any future processing and the future proposal does not offer any resolution.

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

Reviewer 1:
The reviewer praised this as an excellent first step to using Al with fiber composites which can revolutionize lightweight vehicle construction. Through lightweighting, the reviewer added, it can help minimize gasoline use and enable the effective construction of electric vehicles.

Reviewer 2:
The reviewer said it is enabling vehicle lightweighting.

Reviewer 3:
The reviewer remarked that use of lightweight materials such as CFRP and Al will always result in improved fuel efficiency but warned that the focus of the current research as planned will not result directly on fuel savings.

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

Reviewer 1:
The reviewer replied that budget and resources are adequate and it is also to be commended that useful budget details were included in the presentation.

Reviewer 2:
The reviewer stated it seems to be on budget and on time.

Reviewer 3:
The reviewer remarked that this project appears to be a subtask of other similar projects.

Presentation Number: lm115
Presentation Title: Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites
Principal Investigator: Dave Warren (Oak Ridge National Laboratory)

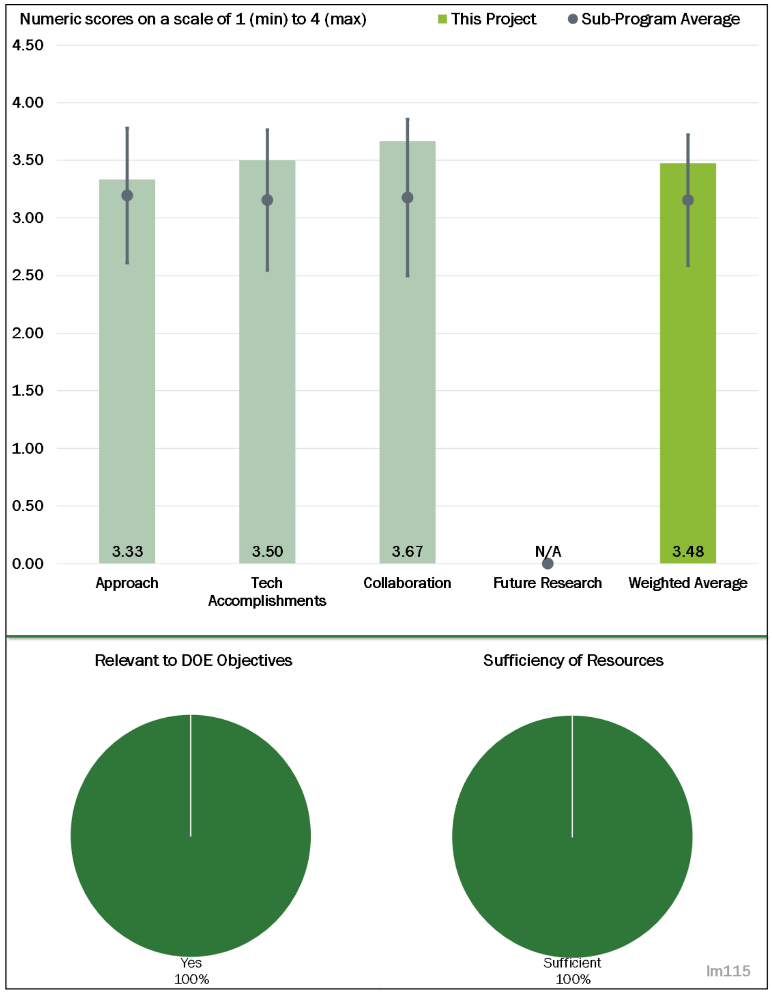

Figure 7-20 - Presentation Number: lm115 Presentation Title: Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites Principal Investigator: Dave Warren (Oak Ridge National Laboratory)

Presenter

Dave Warren, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer praised the excellent progress made in accomplishing the planned tasks for the project.

Reviewer 2:

The reviewer attested that a good methodology and work plan was established and followed.

Reviewer 3:

The reviewer replied that the approach to work performed was thoughtful and comprehensive and agreed that the choice of complex parts and the stage gate (go/no-go) approach was appropriate for the work being undertaken. The reviewer added that the techniques developed to evaluate specimens using ellipsoidal filament cross-sections very innovative. The reviewer would have appreciated (but acknowledged that a limited budget may have precluded) a more robust theoretical foundation regarding flow orientation and resulting fiber orientation, as well as effects of screw design on fiber loading levels and resulting fiber length. The reviewer remarked that insight and development of analytical or physical models would help improve predictions and design of final part.

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 praised the excellent progress during the last performance year and is very pleased to see the predictions are very close to experimental results for the fiber orientation and length.

Reviewer 2:
The reviewer affirmed that the project accomplished what it had set out with well-presented results and explicit recommendations. The reviewer remarked, though, that the costing exercise would have been more valuable with some discussion and insight into the added value of the applications chosen (i.e., beyond weight savings, does extended fatigue or corrosion resistance bring additional consumer value or aid assembly through part reduction, etc.).

Reviewer 3:
The reviewer observed that it appeared project team faced challenges with development of appropriate fiber length attrition models and screw design and added that integration issues between process and structure relationships require further attention.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised the well-balanced teams with excellent collaboration between them.

Reviewer 2:
The reviewer said there was good collaboration with other industry/academia partners.

Reviewer 3:
The reviewer agreed there was a strong collaborative research effort between public, private, and academic stakeholders, remarking that the national laboratory drew upon resources and expertise in a particularly meaningful way. The reviewer added that the use of a major OEM (Ford) and material supplier (BASF) adds significant meaning to the results.

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 replied the recommendation for future research is well documented.

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

Reviewer 1:
The reviewer remarked that the use of higher specific property materials where applications can support the low cost of injection molding is an important factor in successful commercial applications. The reviewer explained that this leads to the most affordable path to weight reduction and as the presenter commented, represents the “lowest hanging fruit” to harvest vehicle weight savings that ultimately improves fuel mileage and emission reductions.

Reviewer 2:
The reviewer replied yes, explaining that the deliverables of this project will enable more lightweight injection molded composite parts in to an automobile for lightweighting, which will increase fuel economy of an automobile and thus reduce the consumption of petroleum.

Reviewer 3:
The reviewer said yes, elaborating that the project painted an appropriate picture of the usage of such materials for variety of applications in the automotive space, adding that the project findings aligned with the needs of the overall industry.

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

Reviewer 1:

The reviewer declared that the project resources are just right.

Reviewer 2:

While agreeing that resources were adequate for the work completed, the reviewer added that this illustrates that more funding of this type of activity is still required to realize the potential of these materials to expand their range of application and drive downward the cost of weight reduction.

Presentation Number: lm116
Presentation Title: Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites
Principal Investigator: Leo Fifield (Pacific Northwest National Laboratory)

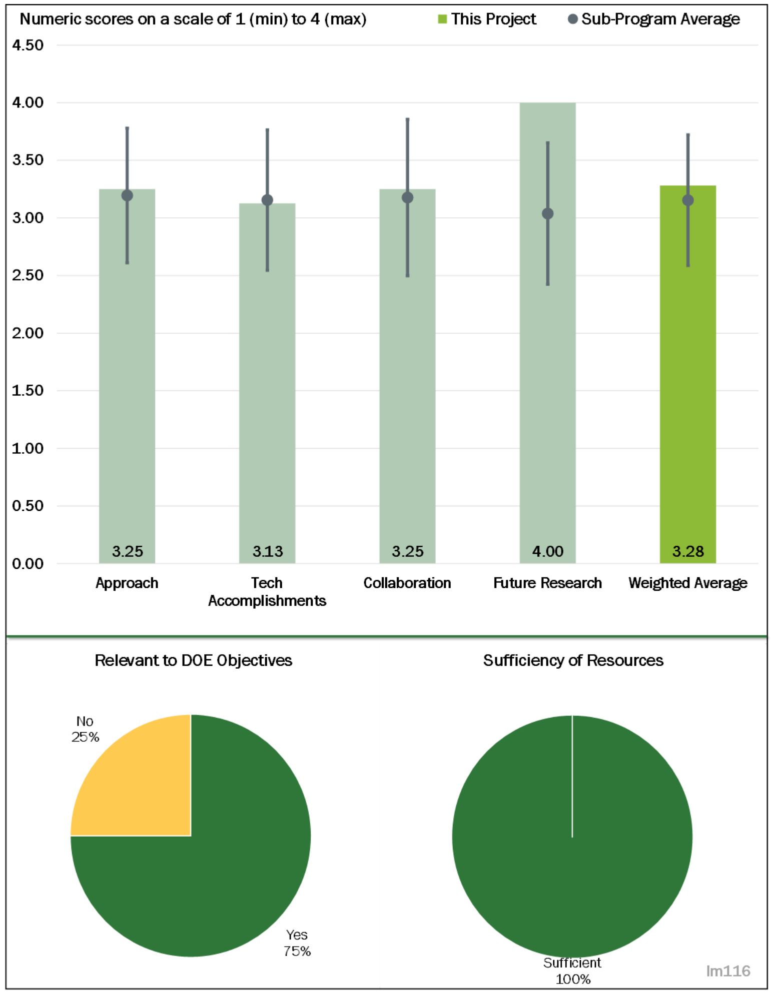

Figure 7-21 - Presentation Number: lm116 Presentation Title: Predictive Engineering Tools for Injection-Molded, Long Carbon Fiber Thermoplastic Composites Principal Investigator: Leo Fifield (Pacific Northwest National Laboratory)

Presenter
Leo Fifield, Pacific Northwest National Laboratory

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

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

Reviewer 1:
The reviewer characterized the work as excellent.

Reviewer 2:
The reviewer praised the well-constructed approach rooted in experimental mechanics and translated to solid analytical formulations that has resulted in useful results from industry can draw.

Reviewer 3:
Noting that the project is over, the reviewer agreed that the basic approach was good, but questioned the way the analyses were done, namely, comparing the experimental results (which have errors that were not shown) and the prediction. The reviewer asserted that the comparison can be a bit more complicated than as indicated.

Reviewer 4:
While agreeing that the initial portion of the approach technically valid, the reviewer found the estimation of weight savings at the vehicle level was not well thought through and as a result the findings were inconclusive.

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 praised the excellent technical progress and solid verification of results. This reviewer's expectation is those results deviating from prediction demonstrate the current need for significant improvement in the micro-mechanics models for resin dominated properties rather than any inherent flaws in the accuracy of

the flow modelling. Regardless, the reviewer believed the results illustrate the ability to provide useful design results with existing approaches, adding that while improvements will be made, the project has demonstrated several important advances. This reviewer would have appreciated more detail associated with the cost exercise and the assumptions that were made.

Reviewer 2:
The reviewer stated that the team should have been allowed to improve models not just "see how good they are."

Reviewer 3:
The reviewer asked if stiffness is the best way to correlate physical properties with the length and the orientation of the fibers. While agreeing stiffness is important, the reviewer wondered if it is the most relevant physical property for the problem at hand. The reviewer thought there should have been a discussion about the choice for that physical property.

Reviewer 4:
The reviewer remarked that one cannot use stiffness performance to measure the effectiveness of mass savings in the vehicle.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer replied good job.

Reviewer 2:
The reviewer said it was a good team.

Reviewer 3:
The reviewer described the team as well rounded to include strong analytical skills from PNNL, the contributions of a major OEM and tier 1 supplier, and the support of software and material suppliers. The reviewer remarked that it is useful to see the contribution of universities. As part of the industrial base, this reviewer would also like to see the number of graduate/undergraduate students that participate and the number of degrees issued where the content was an important part of the advanced degree.

Reviewer 4:
The reviewer commented that the collaboration from Toyota in guiding the project team to use the findings for assessing overall mass and cost savings was not very obvious. However, the reviewer stated there was good collaboration for predictions of flow.

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 stated this is not applicable since the project is over.

Reviewer 2:
Noting that no future work is proposed, the reviewer replied the team cannot be marked down for that since the project is over.

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

Reviewer 1:
The reviewer declared yes, of course.

Reviewer 2:
The reviewer offered that use of high-specific property materials, and in particular discontinuous fiber thermoplastics for injection molding, will be early entry points for lightweighting steel and Al components. Clearly, the reviewer elaborated, lower vehicle weight is a key means of reducing emissions and extending range to displace petroleum and expand the use of plug-in BEVs. The reviewer concluded that improving the fidelity of analytical tools to model vehicles is an important part of successful adoption and use of these materials and that this work advances this aim.

Reviewer 3:
The reviewer replied yes, allowing the use of CF composites is important to vehicle weight reduction.

Reviewer 4:
The reviewer disagreed that the findings of the project were relevant and instead found the findings inconclusive due to the assumptions made for mass and cost savings.

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

Reviewer 1:
The reviewer replied that the resources were sufficient for the described project.

Reviewer 2:
The reviewer remarked that successful completion of this work has demonstrated that resources were available to achieve much of the stated goals. However, the reviewer believed that the remaining gap between target cost and actual cost in terms of dollars per pound of weight saved remains a vexing problem and suggests resources are needed in the development of affordable materials with higher performance and manufacturing systems for lower cost conversion.

Reviewer 3:
The reviewer said the team got the work done but was underfunded.

Reviewer 4:
The reviewer commented that collaboration and contribution from Toyota was not very obvious.

Presentation Number: Im117
Presentation Title: Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications
Principal Investigator: Venkat Aitharaju (General Motors)

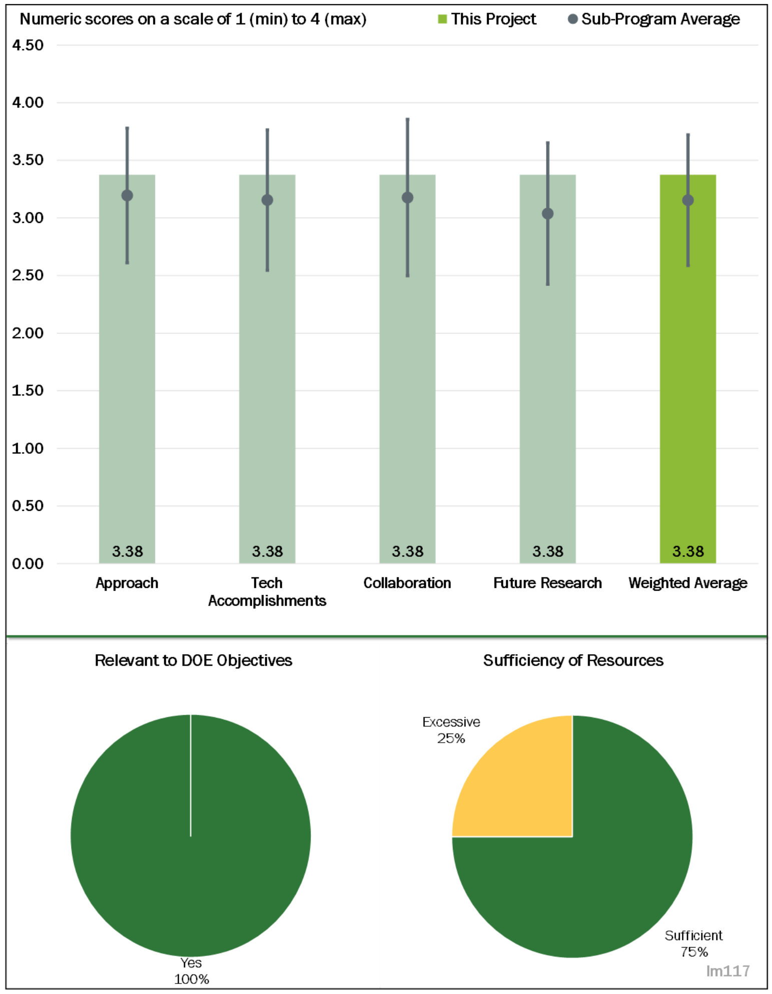

Figure 7-22 - Presentation Number: Im117 Presentation Title: Development and Integration of Predictive Models for Manufacturing and Structural Performance of Carbon Fiber Composites in Automotive Applications Principal Investigator: Venkat Aitharaju (General Motors)

Presenter

Venkat Aitharaju, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer characterized the approach of integrating manufacturing process simulation and performance simulation as being of great importance.

Reviewer 2:

The reviewer replied it was a very logical approach developed and followed through.

Reviewer 3:

The reviewer described it as an integrated approach based on the state-of-art ICME consisting of a diverse team across the entire automotive supply chain that has been used to predict manufacturing and structural performance of automotive CF composites. The reviewer added that the project is well-designed and feasible and noted that 45% of work has been completed by the first-half of the project duration.

Reviewer 4:

The reviewer asked if the project will model the seven baseline assemblies examined in FY 2016 and calculate their respective weight savings and cost per pound saved. The reviewer also wondered whether a model with stochastic simulations always give the same answer, e.g., for energy absorbed during crash, or instead will a model based on stochastic behavior provide a probability distribution of values as the answer.

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 very pleased to see the level of technical accomplishment and progress towards use of high-pressure resin transfer molding (HP-RTM) composites.

Reviewer 2:
The reviewer noted that several major technical accomplishments during FY 2016 have been achieved such as simulation tool development and validation in addition to mapping of manufacturing outcome onto structural models. The reviewer stated that this progress should allow the project team to address remaining challenges and barriers during the remaining 2 years of the project in terms of design and optimizing the automotive assembly in a virtual environment.

Reviewer 3:
The reviewer replied that a number of presentations have been made and that it would be beneficial to the community if the material models generated in this project could be shared and adapted into various commercial software packages.

Reviewer 4:
The reviewer asked whether the fabric and weaves used for draping studies are the same as will be used in eventual assemblies or can the model(s) predict what the "best" weave needs to be for a given performance (i.e., inverse problem). Alternately, the reviewer wondered, will the model(s) be able to handle weaves that are different than those used in the model development stage. Finally, the reviewer inquired what the output is of the multiscale designer software.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer characterized as excellent the collaboration and coordination with other institutions led by an OEM, leading to a recommendable list of accomplishments during the first-half of the project.

Reviewer 2:
The reviewer agreed that the team includes a good combination of industry and academia to address the project challenges and that leveraging DOE-funded Scientific Discovery through the Advanced Computing Institute seems very beneficial to model development. The reviewer added that it would be useful to describe how such a large program is managed with regards to meetings, internal project reviews, data sharing, etc.

Reviewer 3:
The reviewer affirmed that it appears a very nice collaboration with project partners exist and that the tools in use are continuously being refined to increase the degree of accuracy in predictive tools.

Reviewer 4:
The reviewer replied there is good collaboration with software companies and a research university.

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 stated that the proposed future work seems logical in terms of extending the validated tools towards the development of designs and to optimize virtually the automotive assembly.

Reviewer 2:

This reviewer proposes that the project team further validate the technical flow of information for modeling process and predicting structure performance. The reviewer said it was not very obvious whether how the information flow would take place between all the simulation software being used. This reviewer would like to see addressed LS-DYNA related issues for predicting part performance from a structural point of view for future proposed research since LS-DYNA is the dominant analysis tool in the automotive industry. The reviewer suggested that perhaps cross-collaboration with Ford's DOE ICME project could be used to reduce the impact on time and resources.

Reviewer 3:

The reviewer replied that more details about future work would be appreciated.

Reviewer 4:

The reviewer remarked that it is unclear who will perform the cost modeling. Of the baseline assemblies studied in FY 2016, the reviewer would like to know which of these will be addressed in FY 2017 and FY 2018 and what the basis for selection is.

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

Reviewer 1:

The reviewer replied yes, lightweighting is an extremely important to vehicle fuel economy and petroleum displacement.

Reviewer 2:

The reviewer explained that the project focuses on HP-RTM and wet compression RTM, which are the dominant process techniques used by European Union OEMs and will also gain traction in the United States. The reviewer stated that it is very nice to see the project team focus on such a process application method.

Reviewer 3:

The reviewer agreed that this project facilitates overall DOE objectives of petroleum displacement in terms of demonstrating the viability of lightweight automotive designs in a virtual environment.

Reviewer 4:

The reviewer remarked that lifecycle analysis will be useful to compare the use of petroleum-based precursors (for CF and the resin) versus the fuel economy due to lightweighting.

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

Reviewer 1:

The reviewer responded that available resources have been appropriate and timely so far to achieve the stated project milestones.

Reviewer 2:

The reviewer agreed the funding is sufficient.

Presentation Number: lm118
Presentation Title: Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly
Principal Investigator: Srikanth Pilla (Clemson University)

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of three reviewers evaluated this project.

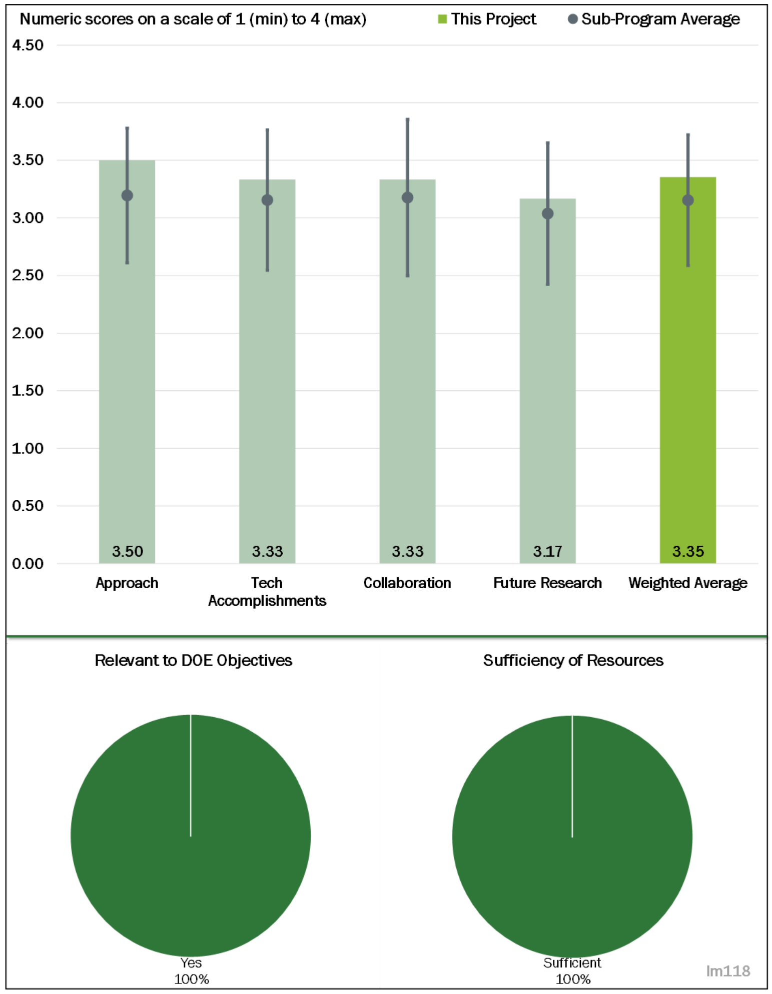

Figure 7-23 - Presentation Number: lm118 Presentation Title: Functionally Designed Ultra-Lightweight Carbon Fiber Reinforced Thermoplastic Composites Door Assembly Principal Investigator: Srikanth Pilla (Clemson University)

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 praised the systematic approach and rational development with good understanding of performance requirements as well as specific targets and action plans. The reviewer added that the project was very well presented.

Reviewer 2:

The reviewer described the project as well designed to explore lightweighting of a door assembly using thermoplastic materials.

Reviewer 3:

The reviewer remarked that the program presentation was based on some rather broad overviews, but it generally showed a thoughtful approach to the downselection process and the justification behind the chosen path. However, the reviewer remarked that the overall concept of lightweighting a door seems to fly in the face of the first characteristic that needed to be maintained (namely, strong open and close) and asked how does one make a light door feel heavy. The reviewer added that perhaps listing this first overemphasized it as a critical parameter, but it was not addressed further in any detail.

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 praised the excellent progress on concept and design development based upon understanding the performance requirements and materials data and added there was good progress on cost analysis.

Reviewer 2:
The reviewer replied that it seems there is good progress on this project from the AMR talk. The reviewer hopes to see more information from this project after clearing protected IP terms from the team members.

Reviewer 3:
The reviewer began by remarking that the technical progress is largely based on faith in the presenter since the details quickly become proprietary and were subsequently “blurred out” in the presentation. The reviewer said that whether there has been some transformational or even novel development is – pardon the pun – not clear. The reviewer asked why not take credit for advances in technology regarding ancillary weight savings opportunities (such as speakers). The reviewer added that 3-kg attributed to these features seems excessive, even if there is no plan to do anything other than outsource that to a different vendor. The reviewer next commented that Slide 18 required considerably more of a detailed discussion, adding that items identified at the extremes of the “hard” and “easy” scale was difficult to rationalize. The reviewer surmised that if throughput to match steel is “easy,” there is not much of a barrier to immediate deployment despite the fact that the earlier comparison table identified thermoplastic composites as being very slow with regard to joining speed, with a “to be determined” (TBD) takt time. On this note, the reviewer remarked, the presentation of the proposed shop floor layout seems well outside the scope of a lightweight materials program (assuming that this part of the analysis is what drove the production time to the “easy” part of the scale). The reviewer pointed out that the specific layout for manufacturing processes are entirely at the discretion of the manufacturer. As far as crashworthiness, the reviewer cautioned, if this portion of the program is still considered a substantial barrier, then it is difficult to judge whether any significant progress has been made. The reviewer concluded that more time spent on this slide really would have helped alleviate some of these questions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer described as excellent the collaboration between the lead, OEM, universities, material suppliers, and prototype suppliers.

Reviewer 2:
The reviewer replied that good interaction and collaboration between partners are evident, adding that consultation and collaborative decision-making are noted for various tasks.

Reviewer 3:
The reviewer agreed that the collaborators are certainly up to the task at hand. The reviewer noted, though, that the presentation listed specific collaborators as well as a number of other entities that are contributing and wondered whether this a group of companies are simply being contracted. The reviewer remarked that the line between collaboration and indirect involvement through sales is not specifically delineated (as an example, the reviewer wondered if Microsoft is a contributor because the presentation is in PowerPoint). The reviewer concluded, however, that the two universities and Honda alone are a solid team.

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 a clear rational plan is provided for future research, adding that it is highly feasible.

Reviewer 2:
The reviewer stated that the meat of the program is still looming, so the future work is critical to any sort of success of the program. Up until this point, the reviewer concluded, specific progress is largely conceptual.

The reviewer’s relatively neutral grade in this category is reflective of that rather than a negative view of the program’s mission.

Reviewer 3:

The reviewer said vigilant about the Class A surface requirement for the door outer.

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

Reviewer 1:

The reviewer remarked that targets from DOE are entirely specific in this area (i.e., target weight savings and cost per mass unit increase). The reviewer concluded that deploying a lighter major chassis component with no critical sacrifices in safety or performance is clearly supportive of efficiency goals.

Reviewer 2:

The reviewer said that use of CF composites will reduce vehicle weight which will lead to fuel economy or contribute to the development of electric cars.

Reviewer 3:

The reviewer replied yes, explaining that this project will help potentially lightweight a door assembly by 13 kg for each door of an automobile and added that these weight saving can translate to reduction in consumption of petroleum.

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

Reviewer 1:

The reviewer affirmed that resources are perfect to accomplish the project tasks.

Reviewer 2:

The reviewer commented that it would appear that Honda is extremely invested in this program and that this is clearly a positive reflection on the team.

Reviewer 3:

The reviewer stated that the budget details show that there is adequate funding to complete the remaining tasks.

Presentation Number: lm119
Presentation Title: Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration
Principal Investigator: Nate Gravelle (TPI)

Presenter

Nate Gravelle, TPI

Reviewer Sample Size

A total of three reviewers evaluated this project.

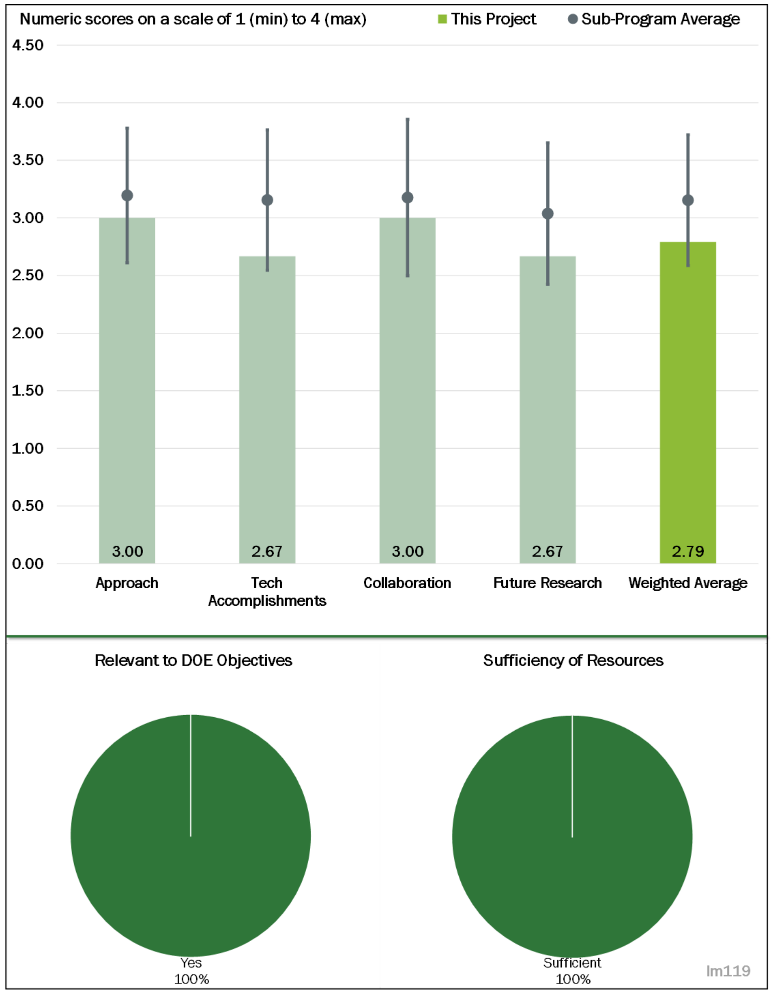

Figure 7-24 - Presentation Number: lm119 Presentation Title: Ultra-Light Hybrid Composite Door Design, Manufacturing, and Demonstration Principal Investigator: Nate Gravelle (TPI)

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 stated that the approach is what would be expected from a company with expertise in composites in order to achieve the lightweighting goals (in this case, of an automotive door) using composite materials optimized to meet specific targets. The reviewer clarified that this is not a drawback or a strength as there is nothing novel in the approach, but added there is ample reason to believe that the program can be very successful.

Reviewer 2:

The reviewer commented that the team started with composite panels for the design, which limited the scope of design. The reviewer suggested the team consider integrating metals in the design for the best use of each material.

Reviewer 3:

The reviewer replied that the approach to meet the target vehicle weight of 42.5% based only on composites limits the cost-effective vehicle lightweighting opportunities. However, the reviewer added it will demonstrate at least what can be achieved if lightweighting is limited only to composites.

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 potential success of the program is dependent upon targets that have not been met, despite the program being at the halfway point and the identification of all target milestones as having been completed. While agreeing that the investigators clearly have expertise in this area, the reviewer said that the progress toward cost targets indicate that they will be difficult to achieve, and the critical characteristic of a final design (safety and performance of the composite door) has not yet been proven. The reviewer elaborated that the latter point is a natural condition for a program that is only halfway through its lifecycle, but it would be expected that a means for achieving cost and weight targets is the first hurdle that must be overcome quickly in order to move to the performance validation phase. The reviewer warned that Slide 21 contains some deflating revelations for a program at this level of progression, adding that a more detailed presentation of the planned approaches for putting the targets back on track would have been compelling.

Reviewer 2:

The reviewer concluded that after 50% project completion to date, an actual approximately 15% versus planned 42.5% weight reduction has been demonstrated. The reviewer said there was no indication given to how close to the final mass reduction while meeting the DOE target of cost of mass saving will be achieved. The reviewer stated that it is important that a multi-material composite-intensive design be considered in order to achieve both DOE mass reduction and savings targets. The reviewer noted, though, that some validation activities such as material characterization and door laminate design optimization have been completed.

Reviewer 3:

The reviewer replied that the current design has not achieved the mass/cost targets.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer affirmed that collaboration is strong for both industry and university partners including among the companies.

Reviewer 2:

The reviewer found that there is some confusion over who is actually collaborating and who is simply performing subcontracted services or are the two treated equally. The reviewer surmised that one would have to believe that there is no distinction, as there are considerable fractions of the funding effort coming from sources other than the DOE, adding that the group of “partners” is substantial.

Reviewer 3:

The reviewer replied that collaboration and coordination have been limited to less than ten institutions and that the role of each institution in the overall project goal was unclear.

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

Reviewer 1:

The reviewer remarked that the “barriers” that have been overcome thus far in the program seem to be limited to the downselection of several structural geometries and the ability to model specific characteristics of the door assembly in order to optimize system performance. While acknowledging that these are no small achievements, the reviewer stated that there is not a clear path for novel approaches that are more favorably indicative that the basic cost and/or weight targets will be met.

Reviewer 2:

The reviewer stated that the plan for future work includes full scale door and vehicle testing which indicates that no alternative designs will be considered to meet the DOE technical targets.

Reviewer 3:
The reviewer replied that it is not clear whether the future research will achieve the project goals of 42.5% mass saving and less than $5 cost increase per pound saved.

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

Reviewer 1:
The reviewer replied yes, lightweighting is an important strategy for petroleum displacement.

Reviewer 2:
The reviewer stated that DOE objectives are specific for this program with regard to weight savings and cost.

Reviewer 3:
The reviewer agreed that this project supports the overall DOE objectives of petroleum displacement but added that the petroleum displacement potential with the proposed lightweight door design is yet to be quantified.

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

Reviewer 1:
The reviewer replied that funding is sufficient.

Reviewer 2:
The reviewer stated that all milestones are complete as shown by the PI, so by this measure the program is progressing as planned. The reviewer characterized this as a positive reflection on the resources allocated, but added that the ability to meet the stated targets is still an outstanding barrier. The reviewer offered that this may be an indication that the resources were not sufficient vis-à-vis the approach to achieving DOE goals, but added that with a substantial portion of the program remaining, there is reason to believe that the achievements to date can be built upon in order to achieve those goals.

Reviewer 3:
The reviewer observed that resources allocated to this project is less than what has been available to the Vehma International Ultra-Light Door Design project.

Presentation Number: Im120
Presentation Title: Ultra-Light Door Design
Principal Investigator: Tim Skszek (Vehma International)

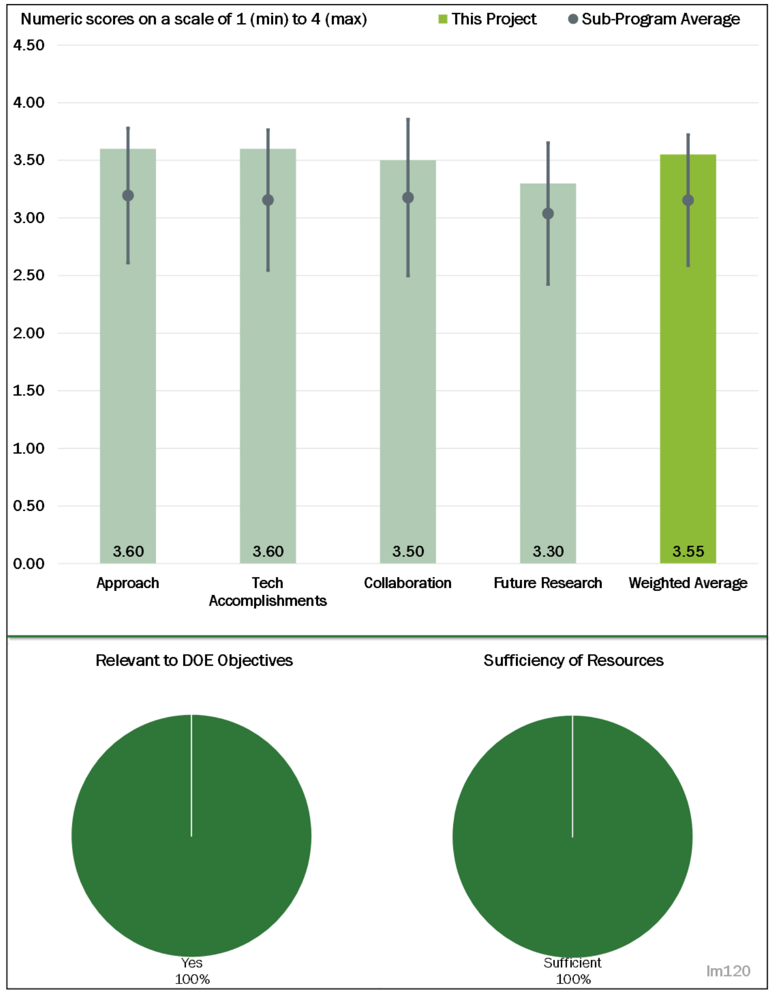

Figure 7-25 - Presentation Number: Im120 Presentation Title: Ultra-Light Door Design Principal Investigator: Tim Skszek (Vehma International)

Presenter

Tim Reaburn, Magna

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 described the approach as outstanding, pointing out that the team realized that lightweighting only the structure would not reach the overall goal so that the team looked at every component in the door assembly. The reviewer explained that the team developed commercially-viable designs for reducing weight from every component and subsystem. This reviewer especially liked the electronic latch which saves 0.77 kg (between the latch and handle), adding that this is in line with the industry move to electronic parking brakes for the same reason, namely, to save weight. The reviewer also said the use of Gorilla glass along with thinner exterior glass are great ideas.

Reviewer 2:

The reviewer remarked that the “no stone left unturned” approach was effective based on the proposed results. While noting the frame lightweighting targets were not as aggressive as with other technologies, the reviewer offered that the consideration of other weight-saving technologies is providing a level of success that has not been achieved in similar door lightweighting programs.

Reviewer 3:

The reviewer explained that the systematic selection approach by taking into consideration major technical barriers was used for the final concept design. The reviewer said it would have been useful to know what specific criteria and the evaluation method were used while evaluating various alternative concept designs.

Reviewer 4:

Noting that the project started with three concepts of different materials to include Al, Mg, and CF composites, the reviewer suggested that the downselection process and decision matrix be provided to the review process and published if possible.

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 pointed out that the project team has exceeded DOE goals and within a 1.5-year timeframe developed multiple designs, completed the analysis, and built full working prototypes.

Reviewer 2:
The reviewer observed that the project achieved 40% mass saving at $2.59 per pound saved for the Al-intensive design and praised this is an outstanding accomplishment.

Reviewer 3:
The reviewer praised the technical achievement to date as superb as shown by an actual door demonstration at the review. The reviewer noted that an actual prototype demonstration was ahead of the schedule and within the budget.

Reviewer 4:
The reviewer explained that with roughly six months remaining in the program, a relatively minor level of weight loss will result in the lightweighting target being achieved, and with the projected cost increase already significantly below the stated goal, there is a substantial amount of allowable expense "banked" for this specific cost reduction strategy, whatever that might be. The reviewer stressed that a clear presentation of the actual costs in each of the component technologies would have been extraordinarily welcome in the presentation, as the program's accomplishments to date are in stark contrast to the cost and weight savings analyses that have been performed by other entities that indicate an "alloy-only" (particularly Al-only) approach will not be capable of meeting stated targets. The reviewer wondered if this indicates that the impending performance/safety targets will not be met or that the cost estimates are egregiously optimistic. The reviewer concluded that the significant accomplishments of this group indicate that this is not the case, but added that any doubts might have been alleviated with a more substantial raw material and/or production cost breakdown.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer enthused that the team has set the bar for working together with eight organizations (give outside of Magna) to complete new designs and prototypes for multiple subsystems. This reviewer does not believe anyone within the industry could have done this any faster.

Reviewer 2:
The reviewer stated that the project has clearly been a team effort with investment by a number of research entities (as underscored by the signed door diagram). The reviewer praised this as a solid overall project with enthusiastic support by stakeholders.

Reviewer 3:
The reviewer praised this project's excellent collaborations among several companies that has produced great results. The reviewer added that it would be great if a university team can join the project since it is important to train students (our next generation of workforce) on how to design with lightweight materials.

Reviewer 4:
Noting that several institutions collaborated on this successful project, the reviewer said the excellent collaboration among them is evidenced by the project's overall timely success. The reviewer added that an OEM participation as one of the collaborators would have been useful.

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 relatively benign "good" ranking is more an indication that the program as presented indicates there is little left to accomplish. Outside of needing less than 1kg of weight savings to achieve the stated DOE goal, the technology seems ready to deploy at a price point well below the perceived balance point for cost effectiveness.

Reviewer 2:
The reviewer commented that future research is the testing of a large number of prototype doors with evaluation of the design and prototypes after each test. The reviewer added that the team will have test results in time to make any recommendations for improvement.

Reviewer 3:
Although the team has achieved a great design of 40% mass saving at $2.59/lb. saved, the reviewer suggested it explore additional mass saving opportunities such as Mg or CF composite inner panels to report dollars per pound saved for those opportunities.

Reviewer 4:
The reviewer stated that the project is expected to be completed by the end of CY 2017 and no future plan in terms of commercialization has been discussed.

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

Reviewer 1:
The reviewer replied yes, a lightweight door is an excellent demonstration of lightweighting opportunities for other vehicle subsystems.

Reviewer 2:
The reviewer answered yes, elaborating that the project has demonstrated a mass reduction of 55-kg per vehicle and that using the normal expectation for weight reduction (including engine downsizing), this would result in a 0.22-L per 100-km fuel economy improvement.

Reviewer 3:
The reviewer agreed that this project supports the overall DOE objectives of petroleum displacement by demonstrating the overall 40% mass reduction in an ultralight automotive door design resulting in an estimated 0.22 L per 100-km of fuel consumption over the vehicle lifetime.

Reviewer 4:
The reviewer responded that DOE goals are reasonably clear in this area, and the project is indicating successful progress toward those goals. The reviewer commented, though, that the emphasis on specific fuel savings per kilogram saved seemed overstated in the presentation (despite the direct references to DOE literature). The reviewer wondered why not agree that those are workshop numbers based on a fleet scale and focus instead on specific platforms. The reviewer added that the project seems quite well-equipped to do that with specifics up to and including door trim details. The reviewer remarked that time was wasted on this type of generality that could have been better directed at cost breakdowns and justifications. Additionally, the reviewer said, it can be argued that the allowable cost per mass unit saved is more of a quality of consumer sensitivities and marketability of new technology versus the price point of fuel (rather than economic savings versus greenhouse gases). The reviewer reiterated that this is unnecessary as a point of emphasis.

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

Reviewer 1:
Remarking that the project is well staffed, this reviewer doubted anyone could have accomplished these goals along with prototyping any faster than this team has.

Reviewer 2:
The reviewer commented that a total budget of about $8.5 million for this fast-tracked two-year project was sufficient to achieve the stated DOE objective and added that a 50% cost share provided by industry was crucial in meeting the stated milestones in a timely fashion.

Reviewer 3:
The reviewer replied that the proof is in the quantified progress figures versus the stated goals of the program.

Reviewer 4:
The reviewer replied that the project was on budget and on time.

Presentation Number: lm121
Presentation Title: Carbon Fiber Technology Facility
Principal Investigator: Dave Warren (Oak Ridge National Laboratory)

Presenter

Amit Naskar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

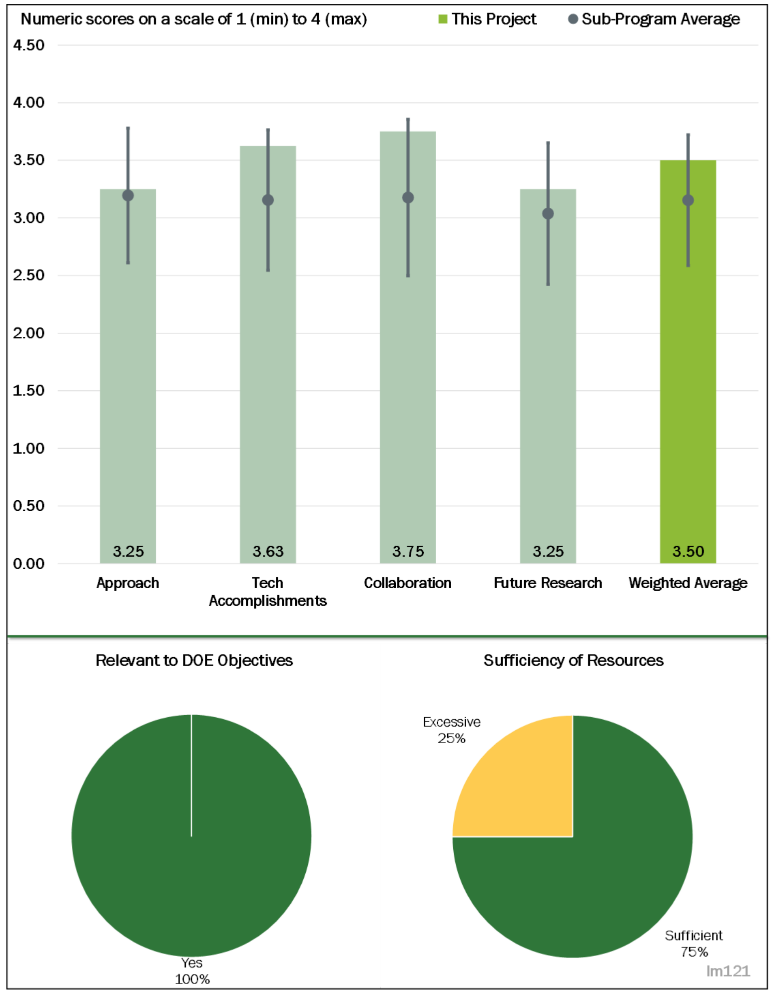

Figure 7-26 - Presentation Number: lm121 Presentation Title: Carbon Fiber Technology Facility Principal Investigator: Dave Warren (Oak Ridge National Laboratory)

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 stated that the team showed an excellent understanding of the barriers that need to be addressed such as the different stretch of the fiber and location where fiber can be obtained.

Reviewer 2:

The reviewer replied there were great examples and output from textile polyacrylonitrile (PAN) and lower cost precursor material, adding that the overview of the precursor historical output in mechanical properties was presented very nicely with well-documented historical performance data.

Reviewer 3:

The reviewer said there is a “feel” that the approach is “shotgun,” with the identification of “commercial” textile grade precursors and the trial/error approach of evaluating being rather costly. Given the market size for using precursor, addressing opportunities to “design” a precursor that optimizes molecular structure (while maintaining the fundamental advantages of low-cost through high-volume, large tow manufacturing) would feel better. The result would be expanded applications, greater consistency, and larger market share to further drive-up volume and further reduce cost.

Reviewer 4:

The reviewer replied it was an effective stepwise approach being used starting with materials and added that there has been much focus on commercialization and less on the technical and scientific aspects of the process. The reviewer said that collaboration with parts users (OEMs) is missing.

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 replied the technical accomplishments and identification of the breakthroughs in development of large-volume CF fiber production, including textile PAN precursors.

Reviewer 2:
The reviewer said the property data generation, process development, and commercialization activities are very good and that the cost reduction in production and energy consumption is interesting.

Reviewer 3:
The reviewer stated that since the team was already able to make a licensing agreement with LeMond, it has met the goals of putting the system into production

Reviewer 4:
The reviewer observed that the pilot-scale manufacturing of 600,000 tow and the demonstrated properties exhibit the potential of this project to yield commercially successful results. The reviewer added that ORNL's licensing to LeMond is further testimony to its accomplishments. The upward trend in mechanical properties is encouraging, but this reviewer would like to see a reduction in variance and focus on a specific material system that yields the most attractive combination of specific stiffness and specific compressive strain (as well as tensile strength) in the lowest possible cost per kilogram tow. The reviewer added that it would be reasonable to expect a tight technical specification be established for the precursor and ask industry to meet that specification and identify costing (as well as means to further drive cost down).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer replied that an impressive list of technical collaboration projects (over 50) has been provided.

Reviewer 2:
The reviewer observed that with CF shipped to 13 different companies for evaluation in many different aspects shows tremendous collaboration and enthusiasm for this project

Reviewer 3:
The reviewer commented that the broad base of technical collaborators presented is impressive and demonstrates the effort the PI has made to enlist the broadest range of technical expertise possible. The reviewer added that the strong number of participants in the supply chain is represented and an extensive number of convertors and end users have contributed to this effort. The reviewer suggested it would be useful for the PI to provide specific information regarding feedback received. In addition, this reviewer would like to see more active collaboration with existing CF manufacturers, remarking that it seems unfortunate that such a resource is underutilized by this sector. More insight into the reason for this gap would be helpful, the reviewer said.

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 there is a well-thought-through set of recommendations on future proposed research and development steps.

Reviewer 2:
The reviewer observed that the research appears to be almost completed and may be moving to the plant level, adding that in order to continue the project in a research environment, the approach to the fundamental science should be better defined.

Reviewer 3:
The reviewer recommended a focus on specific mechanical properties and setting a bar requiring that these properties be met. The reviewer also recommended that a specification or possibly multiple specifications for a range of products should be established based on industry feedback along with associated cost targets. The reviewer added that identifying the specific opportunities for cost reduction, as well as identifying the fundamental barriers, should be included such that the work focuses on those elements that can be tuned to meet target specifications and costs.

Reviewer 4:
The reviewer replied that collaboration with part users (OEMs) seems to be missing.

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

Reviewer 1:
The reviewer enthused that this is a key enabler for addressing many of the technical challenges and efforts such as this further accelerates the use and understanding of CF composites for variety of applications. The reviewer characterized it as a great cornerstone for collaboration among industry partners and an excellent enabler for educating the future workforce needed for the country.

Reviewer 2:
The reviewer observed that the price/demand curve of CF is quite steep and that any movement in terms of cost reduction for a fixed performance will expand the use of CF in automotive applications and have the knock-on effect of expanding other industrial applications (such as wind power) that further displaces petroleum and hydro-carbon consumption. The reviewer conclude that this is essential work that should be supported.

Reviewer 3:
The reviewer offered that the cost of CF is perhaps the largest barrier to its use in automotive applications. The reviewer elaborated that the strength, stiffness, and weight of CF composites make it an excellent "lightweighting" material, but the cost is prohibitive. The reviewer affirmed that trying to use textile materials as a precursor to making CF must be one of the best ways to reduce CF cost, adding that this project attempts to do this and it appears to have been successful.

Reviewer 4:
The reviewer agreed it will contribute to vehicle lightweighting for gasoline and electric cars.

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

Reviewer 1:
The Carbon Fiber Technology Facility at ORNL was clearly able to produce the product to make materials for companies to evaluate.

Reviewer 2:
The reviewer noted that the operation of a CF facility is extremely expensive and that capital expenditures, raw materials, and staff and all that is associated with these require significant resources. The reviewer said that this is clearly understood by DOE and ORNL, adding that the level of funds expended are high but the

potential reward is similarly great. As previously discussed by this reviewer, more collaboration with the established fiber suppliers would be very helpful to offset some of the resource requirements and may lead to measurable results in the short term.

Reviewer 3:
The reviewer said the project seems to be just a little underfunded (by $140,000).

Presentation Number: lm122
Presentation Title: Close Proximity Electromagnetic Carbonization (CPEC)
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

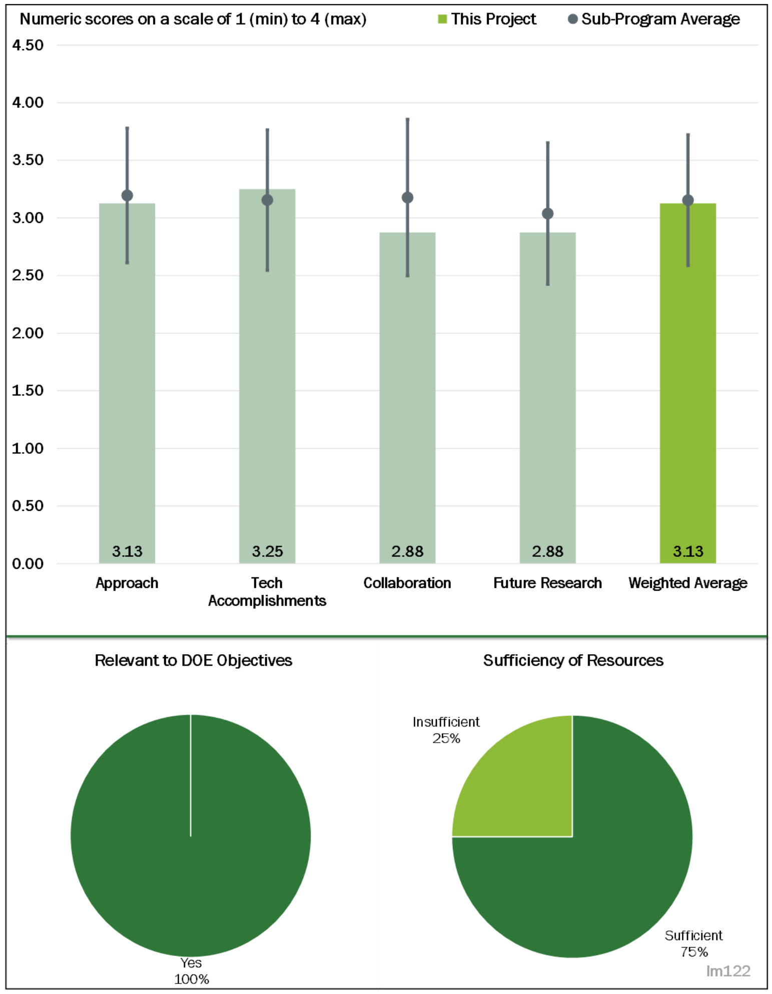

Figure 7-27 - Presentation Number: lm122 Presentation Title: Close Proximity Electromagnetic Carbonization (CPEC) Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Truman Bonds, RMX Technologies

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 described a well-thought-out approach with project milestones established.

Reviewer 2:

The reviewer remarked that the PI provided good background and useful fundamental physics behind the approach to using electromagnetic coupling to achieve thermal input for carbonization of PAN fiber. The practical steps to be pursued were more blurred, the reviewer commented, but some of this is a result of the restrictive nature of public disclosure for this technology. The reviewer added that the project motivation is well expressed and the tasks outlined are adequate.

Reviewer 3:

The reviewer stated that the project is positioned to solve most processing problems effectively, but added that there is less indication as to how the technical challenges with respect to ensuring consistent properties (along and across the fiber) are addressed.

Reviewer 4:

The reviewer observed that although dielectric heating initially appears as a method to efficiently carbonize polymers strands, the variability in the impedance of the fiber causes significant variability in the localized temperature in the fiber. As shown in Slide 16, the reviewer explained, the resistance along the strand varies from 76-ohms to 1295-ohms, more than an order of magnitude. Furthermore, the resistance values do not trend in one direction along the fiber but fluctuates. The reviewer noted that the team uses an average resistance to tune the energy source and as a result, the source frequency will be significantly off resonance for most of the fiber. The reviewer said that what this will mean is that part of the fiber will heat up too much (melting was observed) or not heat enough and therefore the fiber will not be carbonized.

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 there is an excellent benefit from the use of computation electromagnetic modeling and evaluations of design concepts prior to designing and building a prototype.

Reviewer 2:
The reviewer described excellent progress on milestones 1 to 5, but added that it was difficult to judge from the property data presented if milestone 6 on fiber properties is likely to be achieved.

Reviewer 3:
The reviewer stated that the contractor has demonstrated the feasibility of the approach and made solid progress in application at a very limited level. The results, however, suggest scalability and demand follow up. The reviewer commented that while the trend of increasing modulus (and degree of carbonization) versus peak strain at failure suggests a level of risk (i.e., insufficient peak strain), it must be understood that other critical process parameters are not in play (such as fiber tension, etc.). The reviewer concluded that the suggestion that the technology may also be applied in the range of high-temperature carbonization represents additional cost reduction opportunities and must be further explored.

Reviewer 4:
The reviewer replied that as outlined in the milestones, the team has accomplished its tasks and have now created a system for testing. However, the reviewer questioned the go no-go milestone 4 (M4) question. In particular, the milestone claims stable processing of the fiber, but in the speaker's own words, there was melting of the fiber.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer agreed that the project partner is well suited based on the project needs and objectives. The reviewer noted that future project partner selection was also identified to carry on project findings for larger scale up.

Reviewer 2:
The reviewer stated that while the depth of collaboration is limited (ORNL and RMX Technologies), the fundamental skill sets for success development of the technology is adequate. The reviewer suggested it might be helpful to include collaboration with an academic institution to support material characterization or provide specific targets for material performance.

Reviewer 3:
The reviewer observed that only two partners, ORNL and RMX Technologies, are involved with two other RMX collaborators and said that more partners (such as OEMs, composite manufacturers) should be sought.

Reviewer 4:
The reviewer remarked that the team collaboration with RMX on the electrical side appears to be going well, noting that they have been able to make the equipment. However, the reviewer said there appears to be lack of collaboration with a partner that can quantify the efficiency and losses of the conventional process for the low temperature carbonization stage.

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 agreed that the proposed future research is very consistent with the end goals of the project and scale up.

Reviewer 2:
The reviewer remarked that although the proposed future research identifies the further measurement of the fiber for strength, what really needs to be researched is what are the local time and temperatures that exists along the fiber given the variability of the process. The reviewer asked what is causing the temperature spikes that cause melting and how is the efficiency of the electrical system being measured.

Reviewer 3:
The reviewer commented that the proposed effort contains little detail with respect to specific technical details but is adequate to suggest that current technical gaps will progress toward a solution or at least a resolution. This reviewer would like to see more specific targets for "require mechanical properties," and that an explicit target based upon properties of fiber produced with conventional thermal processes would be useful. In addition, the reviewer said a complete cost model that provides detail on the opportunity for cost reduction in terms of dollars per kilogram would be very useful to assess value of work.

Reviewer 4:
The reviewer cautioned that it is not clear if the technology can provide consistent fiber properties across the tow, across the fiber cross section, and along the fiber length. In addition, the reviewer said that the future research does not explain how these consistent properties can be obtained with the current technology when scaled-up.

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

Reviewer 1:
The reviewer stated that any research focused on reducing the cost of processing CF supports the stated DOE objective because CF cost is one of the most significant barriers to expanded use of these high specific property materials. The reviewer added that cost reduction of any magnitude will expand applications and enable applications in automotive structure, thus reducing weight and displacing the use of petroleum.

Reviewer 2:
The reviewer replied that carbonization of CF is certainly one of the key elements contributing to the overall cost and that the project certainly supports future developments of reducing cost of CF composites, adding that the research continues to pave ways for further evaluation of precursors as well.

Reviewer 3:
The reviewer noted that the project tries to reduce energy in the production of CF and that if successful, it may potentially lower the cost of CF and increase the use in automotive applications.

Reviewer 4:
The reviewer said it will be contribute to cost reduction in vehicle lightweighting but cautioned that with no OEM or composites manufacture present as partners, the project may not have a sharp focus.

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

Reviewer 1:

While agreeing that resources appear adequate, this reviewer is not fully aware of the costs required to scale the bench tests to continuous fiber conversion but added that the work is significant enough that the reviewer encourages DOE and industry to support this effort.

Reviewer 2:

The reviewers affirmed that there are sufficient resources (budget and expertise) to produce a scaled-up Close Proximity Electromagnetic Carbonization (CPEC) furnace, adding that ORNL can, of course, provide the expertise on the materials characterization aspects.

Reviewer 3:

The reviewer replied that currently the team appears to lack the ability to accurately measure the localized physical properties of the fiber in a consistent manner. The reviewer also noted that it was also pointed out by the speaker that the team does not have enough details on the expected properties or process of the commercial low-temperature carbonization process, which might make it difficult to truly evaluate the fiber properties and make an overall efficiency comparison.

Presentation Number: lm123
Presentation Title: Safety Statistical Analysis
Principal Investigator: Tom Wenzel (Lawrence Berkeley National Laboratory)

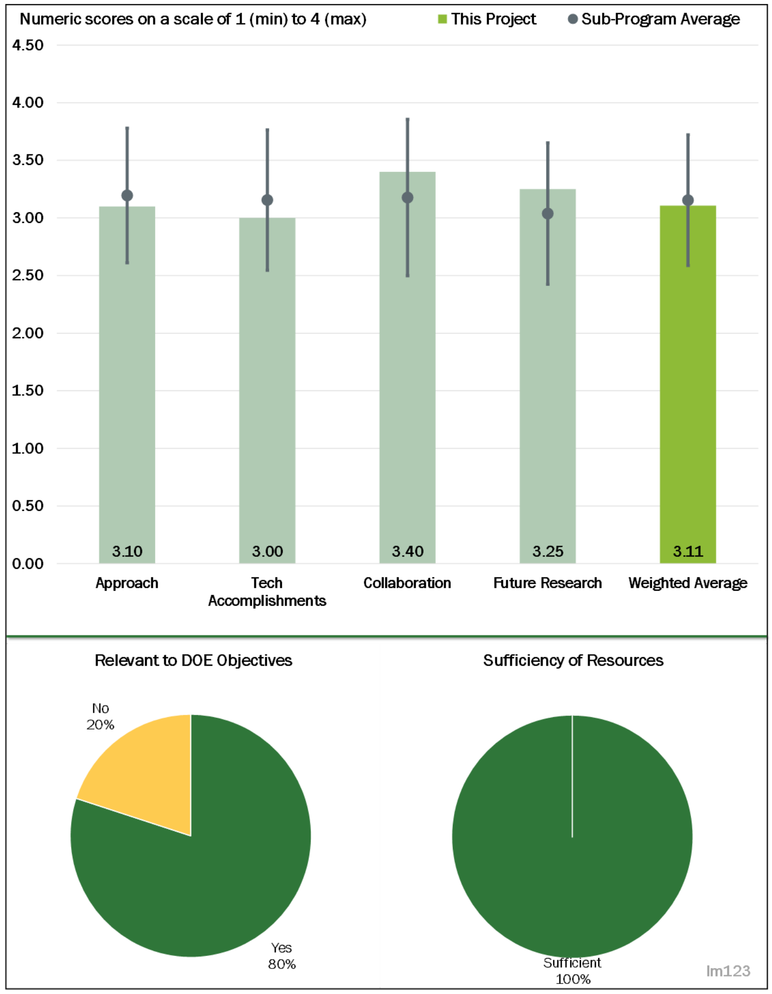

Figure 7-28 - Presentation Number: lm123 Presentation Title: Safety Statistical Analysis Principal Investigator: Tom Wenzel (Lawrence Berkeley National Laboratory)

Presenter

Tom Wenzel, Lawrence Berkeley 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 stated that the project is focused upon facilitating collaboration among the primary regulatory and policy agencies, validating, and enhancing relevant analyses, elaborating that activities are tightly targeted at informing decision-making related to specific requirements such as the mid-term review for light-duty fuel economy.

Reviewer 2:

The reviewer observed that the team's approach to consider factors impacting vehicle fatalities based on vehicle weight, styles, and occupancy can be used both to influence automotive manufacturers' decisions and also decisions of the public. The reviewer noted that the team used a combination of data sources and studied many different combinations of potential causes. Finally, the reviewer suggested that if something could be improved, it would be to get a bigger dataset, although this may not be available.

Reviewer 3:

The reviewer commented that the project seemed to be well-designed and was extremely interesting, although the dataset was limited and the degree of accurate representation of the whole was not clear. The reviewer commented that it would have been helpful to know which 13 states were represented and where they ranked in terms of key metrics such as annual traffic fatalities and serious injuries per population and rate of crash per miles driven per year. The reviewer suggested a few possible improvements for presenting to a more general audience might include the following: what and who defines a serious injury and is that definition consistent from state to state; separate serious injury from fatalities and determine how casualty rankings change, both in the 13-state population and over the 50 states; and whether it matters where in the vehicle that mass is removed. The reviewer elaborated that, for instance, as there have been mass reductions in the body, frame, and engine, there have been concomitant increases in mass due to comfort, safety, automation, entertainment, and communications.

The reviewer remarked it would be interesting to compare the effect of lightweighting in more detail in a future study where subsets of vehicles with certain structural mass reduction strategies (but overall minor changes in total weight) are considered. The reviewer expressed concern that there is more impact of lightweighting than is obvious since it matters where the mass was removed as much as mass being removed. The reviewer clarified that if structural mass is reduced but weight is added for non-structural items, then the vehicle might not appear to be lightweighted on a total mass basis. When this vehicle is compared to the population of cars that saw more of a total mass reduction (perhaps due to less non-structural additions, as well as due to international structural lightweighting), it would be the case that the outcomes of the population of lightweighted vehicles might look very similar to this vehicle in the heavier class because structurally they are similar. The reviewer realizes it might not be possible to account for such nuances, but without analyzing for them, the comparisons and conclusions may be questionable. This may also help to better predict future outcomes.

The reviewer asked that because more SUVs and larger cars are selling more recently, and if a larger portion of older cars are smaller, if the data and analysis are skewed. The reviewer inquired if because younger drivers tend to drive older, cheaper (often lighter) cars built with lower safety standards, it these factors also influence the age/gender/etc. (although that influence is not necessarily actually free of lightweighting). The reviewer asked if the likelihood of younger drivers in older, lighter cars was accounted for.

Vehicle velocity seems to have not been emphasized. It would be interesting to bin the data, based on crash analysis (which would not have specific velocity at time of impact data but would have qualitative data) into low, medium, and high velocity, and asked whether lightweighting is more impactful as a function of velocity (i.e., did the crash occur on an interstate at 70 mph or on a backroad at 35 mph). This would be particularly interesting on a state-to-state basis, and would also be interesting to separate by age, gender, and era of vehicle.

Reviewer 4:

The reviewer stated that the project does not present an argument as to why safety is related to mass and suggested perhaps a survey should be conducted first on this question. The reviewer also remarked that the analysis does not consider a number of variables such as the use of cell phones, mass times velocity, the impact strength of the materials in the body construction, time of the year, road conditions, or day of the week. The reviewer noted that 2016 and 2005 have very different driver behaviors and further suggested perhaps two sub groups, 2005-2010 and 2011-2016 can be compared.

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 stated that a lot has already been accomplished under an aggressive schedule. The reviewer added that while this schedule was necessary to meet regulatory requirements (such as the mid-term review), nevertheless, a lot has been completed and (just as importantly) properly disseminated.

Reviewer 2:

The reviewer concluded that the project seemed to have accomplished its goals within the limits of data availability. The reviewer reiterated that again, it seemed to be a very well-constructed and executed data analysis, but added how representative it is of the whole is obviously still unclear.

Reviewer 3:

The reviewer remarked that much data analysis has been performed but that more effort should be spent on identifying variables.

Reviewer 4:
The reviewer commented how the project will help achieve a 40% reduction is fuel consumption is questionable, adding that for one thing, it will be difficult to prove in the short term that people will purchase lighter vehicles based on this study. However, the reviewer also stated that this analysis is important and should be done because vehicle safety is obviously critically important. The reviewer concluded that processed data like this will influence how future vehicles are designed, making them safer and hopefully lighter at the same time.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that under this project, the DOE Lawrence Berkeley National Laboratory is collaborating with the National Highway Traffic Safety Administration (NHTSA), the U.S. Environmental Protection Agency (EPA), and the California Air Resources Board (CARB). The reviewer enthused that these are exactly the appropriate parties to work with on this effort, as they are the ones making regulatory decisions.

Reviewer 2:
The reviewer remarked that there is good collaboration with NHTSA, EPA, and CARB.

Reviewer 3:
The reviewer noted that the team collected data from large public entities to generate as much information as possible. Although more data would be better, the reviewer acknowledged that as highlighted by the speaker, it is currently unavailable. The reviewer added that this type of work may increase the amount of data collected in the future, for example, having all states collect vehicle identification numbers when vehicles are registered.

Reviewer 4:
The reviewer stated there is collaboration with NHTSA, EPA, and CARB, adding that a question comes to mind if data from other parts of the world can be used or used to compare.

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 stated that the project focus is well laid out and intends to collect more data as it becomes available.

Reviewer 2:
The reviewer observed that there is a specific list of remaining activities, tightly focused upon regulatory requirements. The reviewer also noted that the project is 90% complete and is scheduled for completion in September 2017, so there are not that many activities remaining, and those that are appear to be important pieces in need of development.

Reviewer 3:
The reviewer stated that the project ends this year.

Reviewer 4:
The reviewer asked how will the results be verified and can they be validated.

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

Reviewer 1:
The reviewer remarked that as vehicles are designed to reduce weight to reduce petroleum consumption, safety cannot be compromised. The reviewer further remarked that this research does a statistical study of auto fatalities and highlights that other factors beyond vehicle weight are the greatest influence on vehicle safety. Observing that it has also shown that it is not overall mass that influences safety but the differences in mass that have a greater impact, the reviewer praised this type of research as invaluable and said it should be continued on a longer term bases to observe the trends in fatalities.

Reviewer 2:
The reviewer replied yes, adding that the project is focused on the impact of changes in vehicle weight and size. The reviewer elaborated that changing these parameters requires looking at results upon both safety and fuel economy (and thus overall energy consumption) and that the increased emphasis upon fuel economy is driving opportunities for implementation of VTO technologies, particularly lightweight materials for increasing efficiency without necessarily changing vehicle size.

Reviewer 3:
The reviewer said yes, adding that the project allows DOE to quantitatively assess the health and safety aspects of vehicle lightweighting, which is a key piece in the strategy to displace petroleum.

Reviewer 4:
The reviewer commented that the project can only contribute to lightweighting if the outcome is that light weight vehicles are not a safety risk, but since the outcome cannot be predicted, this project might or might not support DOE objectives.

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

Reviewer 1:
The reviewer replied that funds appear sufficient.

Reviewer 2:
The reviewer said no comment.

Reviewer 3:
The reviewer remarked that the funding might be sufficient for the work planned, but it certainly is not sufficient for reaching a convincing outcome.

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Acronyms and Abbreviations

°C	Degree Celsius
µm	Microns
3GAHSSS	Third-Generation Advanced High-Strength Steel
Al	Aluminum
AMR	Annual Merit Review
BEV	Battery Electric Vehicle
CAE	Computer-Added Engineering
CARB	California Air Resources Board
CF	Carbon Fiber
CFRP	Carbon Fiber-Reinforced Polymer
CPEC	Close Proximity Electromagnetic Carbonization
CY	Calendar Year
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
EPMA	Electron Probe Micro-Analyzer
Eu	Europium
EV	Electric Vehicle
FBJ	Friction Bit Joining
FCA	Fiat Chrysler Automobiles
FLD	Forming Limit Diagram
FSS	Friction Stir Scribe
FSW	Friction Stir Weld
FY	Fiscal Year
GHG	Greenhouse Gas
GM	General Motors
H/D	Hydrogen/Deuterium
HAZ	Heat-Affected Zone

HPDC	High-Pressure Die Cast
HP-RTM	High-Pressure Resin Transfer Molding
ICE	Internal Combustion Engine
ICME	Integrated Computational Material Engineering
IP	Intellectual Property
LCA	Life-cycle analysis
MD	Molecular Dynamics
Mg	Magnesium
Mn	Manganese
MYPP	Multi-Year Program Plan
NDE	Non-Destructive Evaluation
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PAN	Polyacrylonitrile
PHS	Press-Hardening Steels
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
RE	Rare Earth
SCC	Stress-Corrosion Cracking
SUV	Sport Utility Vehicle
TWB	Tailored-Welded Blanks
UHSS	Ultra-High Strength Steels
USAMP	United States Automotive Materials Partnership
VTO	Vehicle Technologies Office
Zr	Zirconium

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