

**2021 Vehicle Technologies  
Annual Merit Review  
June 21– 25, 2021**

**Guidelines and Slide Examples  
R&D Oral and Poster Presentations**

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# Changes at a Glance for 2021

- All oral presentation and posters must be turned in to ORAU ([VTAMR@ORAU.org](mailto:VTAMR@ORAU.org)) no later than **May 14, 2021**.
- **Please NOTE:**
  - The AMR will be hybrid (virtual/in-person).
  - The Checklist will not be required but we strongly suggest that you follow it when preparing your presentation material.
  - Please use a 16:9 aspect ratio for your slides.

## General Note

- These instructions apply to both oral presentations and posters unless we note a distinction between the two.

# Submission Deadline

Presentations are due to  
[VTAMR@ORAU.org](mailto:VTAMR@ORAU.org) no later than

**May 14, 2021**

**No exceptions!**

# Legal Indemnification

**FOR INFORMATION ONLY. DO NOT INCLUDE IN PRESENTATION.**

By submitting a presentation file to Oak Ridge Institute for Science and Education (ORISE) for use at the U.S. Department of Energy's (DOE's) Vehicle Technologies Office Annual Merit Review Meeting and to be provided as hand-out materials, and posting on the DOE's website, except for employees of the Federal Government and DOE laboratory managing and operating contractors, the presentation authors and the organizations they represent agree to defend, indemnify and hold harmless ORISE, its officers, employees, consultants and subcontractors, and the DOE from and against any and all claims, losses, liabilities or expenses which may arise, in whole or in part, from the improper use, misuse, unauthorized use or disclosure, or misrepresentation of any intellectual property claimed by others. Such intellectual property includes copyrighted material, including documents, logos, photos, scripts, software, and videos or animations of any type; trademarks; service marks; patents; and proprietary, or confidential information.

Employees of Federal Government agencies and DOE laboratory managing and operating contractors collectively represent and warrant that they have acquired the rights and/or permission for use of all intellectual property, as listed above and claimed by others, that is needed for developing and submitting a presentation file to ORISE for use at the DOE's Vehicle Technologies Office Annual Merit Review Meeting, and to be provided as hand-out materials, and posted on the DOE's website.

# Creating Your Presentation Files

- ❑ Your presentation is public and will be posted to the DOE Vehicle Technologies Office (VTO) Annual Merit Review (AMR) website.
- ❑ You are required to create the following two files:
  1. A Microsoft PowerPoint file following the instructions and guidelines contained within this PowerPoint template. Acceptable formats for presentations are either .ppt or .pptx
  2. Once your PowerPoint presentation is complete, you must create a PDF version of your PowerPoint presentation following the instructions in this document.
- ❑ You may design your slides on either a PC or a Mac.

## Naming Your Files

- ❑ Use the file name that ORAU sent you in your presentation request email to name your electronic PowerPoint and Adobe files:

Proj#\_PI LastName\_2021\_o

Example: ACE002\_smith\_2021\_o



# Overall Presentation Structure

- **Primary Presentation:** These are the slides you will actually be presenting.
  - **Maximum 15–20 slides** for 30-minute time slots
  - **Maximum 8-10 slides** for 15-minute time slots
  - Please only include work that has taken place since the 2020 AMR.
- **Technical Backup Slides:** These will be included in the presentation file, but are intended primarily to answer questions or provide supplemental information. These will be posted on the VTO AMR website.
  - **Maximum 5 slides**
  - Place these slides after the main presentation and separate them with a divider that says “*Technical Backup Slides.*”
- **Reviewer-Only Slides:** These will not be posted on the VTO AMR website.
  - We do not require reviewer-only slides, but we recommend that you prepare slides to elaborate on issues of interest to the reviewers
  - There is no limit to the number, but you should limit the number of slides to essential information and not overwhelm the reviewers
  - Place these slides after any “Technical Backup” slides and separate them with a divider that says “*Reviewer-Only Slides.*”

# Formatting Your Presentation

- ❑ Please use a 16:9 format for your presentation:
  - Design → Slide size → Widescreen (16:9) for PCs; File → Page Setup → Slides sized for → 16:9 for Macs.
  - Adjust your slides according if you use slides from last year.
- ❑ Do not use proprietary fonts. All fonts in the presentation must be standard across Windows and Mac platforms or information may be lost when creating the Adobe PDF version of your presentation.
- ❑ Use only Arial, Times New Roman, Courier New, Verdana, or Trebuchet MS.
- ❑ Use at least a 12-point font. Fonts should be large enough that audience members in the back of the room can read the slides.
- ❑ Ensure there is high contrast between text and background for best readability. We recommend a white background along with black or dark text. Light or gray text is hard to read at a distance so adjust your template accordingly.
- ❑ Please remove any copyright indicia from your company template so that your presentation can be posted on the AMR website.
- ❑ Spell out acronyms and chemical formulas the first time that you use them.
- ❑ Add Alt Text to all graphics, tables, and charts.
- ❑ Fill out the Properties box for your presentation.

# Adding Images to Your Presentation

- ❑ Do not Copy/Paste images into your presentation.
- ❑ Insert the image using the “Insert/Picture/File name” menu option of PowerPoint rather than Copy/Paste.
- ❑ Insert the image using “Insert/Picture/Picture From File” menu option of PowerPoint rather than Copy/Paste for Mac users.
- ❑ Crop images in an image processing software instead of PowerPoint. Save the images as an external file (.jpg and .png file formats work well).
- ❑ Inserting original images into your presentation works best for preserving image clarity. If originals are not available, it may be an indication the image is copyrighted.

# Animations and Videos

- ❑ Use animated text and/or figures only if absolutely necessary. Unnecessary animations can distract the audience from your message.
- ❑ Be aware that animations do not convert to PDF and animated information may not be visible to reviewers or in the final PDF posted on the VTO AMR website.
- ❑ Videos do not translate to PDF reliably and will not be posted on the VTO AMR website.

# Content Restrictions

- ❑ Your presentation is public and will be posted on the VTO AMR website.
- ❑ You must include the phrase “This presentation does not contain any proprietary, confidential, or otherwise restricted information” on at least the first slide (you may put on all slides if you wish).
- ❑ Do not include any proprietary or confidential information. It is your responsibility to ensure that any subcontractor information is not proprietary or confidential.
- ❑ You must remove the copyright indicia on your company template if that indicia is part of the template; otherwise, we cannot post your presentation on the VTO AMR website.
- ❑ Your presentation may not include any slide that has “Official Use Only” or “Sensitive” or any similar wording, or information that your organization might construe as being in such categories.
- ❑ You must include the phrase “Any proposed future work is subject to change based on funding levels.” on all slides with future-looking statements.

# Copyright Restrictions

- ❑ If you use any **copyrighted information or graphics or intellectual property**, it must be properly attributed.
- ❑ Do not assume subcontractor information may be used without their approval.
- ❑ Do not assume that information or images published on a website can be used without permission.
- ❑ If you use copyrighted graphics (including copyrighted photos and journal and magazine covers), you must provide written permission along with your submitted file for it to be accepted by DOE for the purposes of the AMR.
- ❑ Intellectual property includes copyrighted material, including documents, logos, photos, scripts, software, and videos or animations of any type; trademarks; service marks; patents; and proprietary or confidential information.
- ❑ Also see the indemnification statement on page 7.

# Use of Logos

- ❑ **Do NOT** use the DOE logo or seal in your presentation. Some examples include:



- ❑ **Do NOT** use the EERE slide template.
- ❑ If you use corporate logos for organizations other than your own, secure permission for use.

# 30-Minute Oral Recommended Slide Order

- Title Slide - must include Project ID, name of principal investigator, name of presenter if different, and “This presentation does not contain any proprietary, confidential, or otherwise restricted information.”
- Overview Slide - must include timeline, budget, barriers, and partners
- Relevance
- Milestones (if not included as part of Approach)
- Approach
- Technical Accomplishments and Progress
- Responses to Previous Year Reviewers’ Comments
- Collaboration and Coordination with Other Institutions
- Remaining Challenges and Barriers
- Proposed Future Research
- Summary Slide
- Technical Back-Up Divider Slide
- Technical Back-Up Slides
- Reviewer-Only Divider Slide
- Reviewer-Only Slides
  - Publications & Presentations
  - Critical Assumptions & Issues



# 15-Minute Oral Recommended Slide Order

- Title Slide - must include Project ID, name of principal investigator, name of presenter if different, and “This presentation does not contain any proprietary, confidential, or otherwise restricted information.”
- Overview Slide - must include timeline, budget, barriers, and partners
- Relevance
- Approach
- Technical Accomplishments and Progress
- Collaboration and Coordination with Other Institutions
- Proposed Future Research
- Summary Slide
- Technical Back-Up Divider Slide
- Technical Back-Up Slides
- Reviewer-Only Divider Slide
- Reviewer-Only Slides
  - Publications & Presentations
  - Critical Assumptions & Issues

# Preparing your PowerPoint for Web-Publication / PDF

- ❑ You must create your web-ready PDF file (the file that will be published on the VTO AMR website) using the following instructions on the next pages (p. 19-24) to:
  - Add Alt Text
  - Add presentation detail information
  - Create and verify the final PDF.

# Adding Alt Text to Your Presentation

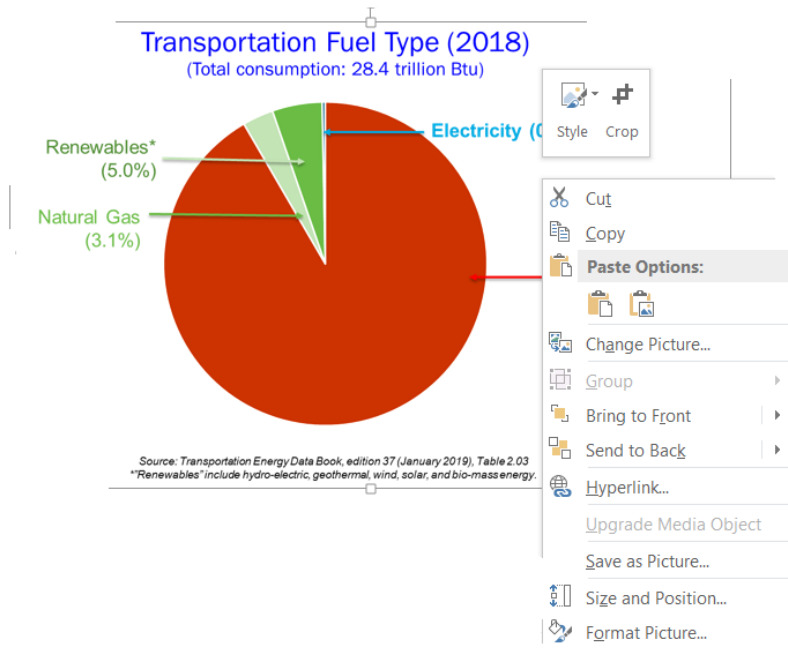
- ❑ You must add alternate text (Alt Text) to key graphics, charts, and tables on each slide.
- ❑ Alt Text helps visually impaired people who use screen readers to know what the picture shows.
- ❑ Be accurate and succinct. You do not have to say “image of...” or “graphic of....”

A good Alt-Text example of a picture of a crowd at a basketball game:

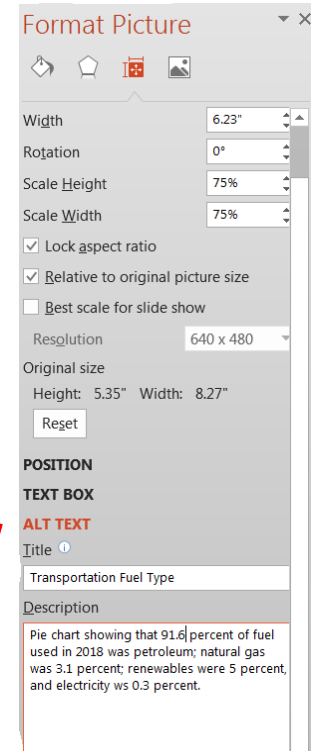
*“A large, diverse group of cheering students, standing up, and fist-pumping on the bleachers of a basketball game.”*

# To Add Alt Text to a Chart, Graph, or Image

*Note: These instructions are for PowerPoint 2013. If you have a newer version, you may be able to right click on the graph or chart and select “Edit Alt Text” directly from the menu.*



1. Right click on the graph or chart and select “Size and Position...”

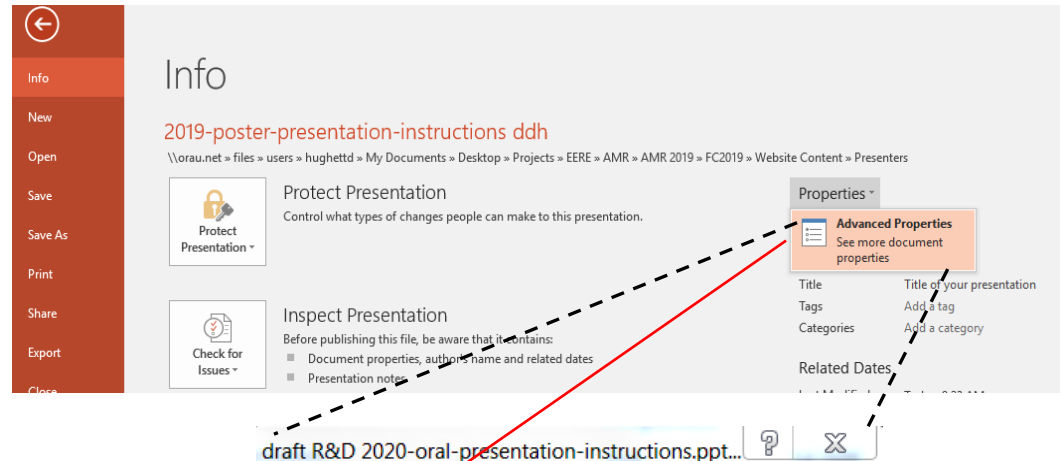


2. Select the “Alt Text” option and enter the **Title** and a short brief **Description** of the chart

3. Close the Format Picture pane to return to the PowerPoint slide

# Adding Presentation Detail Information

- Under the **File** tab, select **Info**
- Click on “**Properties**” and then select “**Advanced Properties**”



On the “**Summary**” tab of the pop up window, complete the following fields:

- **Title:** Enter the title of your presentation
- **Subject:** Substitute your **Project Id** into the subject
- **Author:** Enter the **PI Name** and **Company**

draft R&D 2020-oral-presentation-instructions.ppt...

General Summary Statistics Contents Custom

Title: Oral Presentation Guidelines and Examples

Subject: Project ID, 2020 VTO Annual Merit Review

Author: Principal Investigator Name, Company

Manager:

Company:

Category:

Keywords:

Comments:

Hyperlink base:

Template:

Save preview picture

OK Cancel

- **Save preview picture:** Make sure this box is checked
- Press **OK**

# Creating Final Version of Your Presentation

- ❑ Once your PowerPoint presentation is final, you must minimize your PowerPoint's file size.
- ❑ Do this by using the “[Save As](#)” option to save the final version of your file as a PowerPoint presentation.
- ❑ Doing a simple “Save” command will not minimize file size.
- ❑ You can “Save As” an existing PowerPoint filename if needed.

# Creating PDF Version of Your Presentation

- ❑ You are also required to submit a PDF version of your presentation.
- ❑ After saving your PowerPoint file using the “Save As” option, save the file as a PDF using the same naming conventions as your PowerPoint file.
  - If you have Adobe Acrobat Pro software, you can use the Acrobat PowerPoint plug-in or select “Save As Adobe PDF” to create your PDF
  - If you do not have Acrobat Pro, click “Save As” and select “PDF” from the Save As type menu.
- ❑ Click the “Options” button in the Save As window and make sure to check the box to enable accessibility tags. Look for text that says “Document structure tags for accessibility” or “Enable accessibility and reflow with tagged Adobe PDF.”
- ❑ Click “Save”.
- ❑ Select “NO” if asked if you would like to convert the presentation’s speaker notes to text annotations in the PDF.

# Verifying PDF File

After you created the PDF,

- ❑ Scroll through the document and look at every page to ensure the PDF matches the PowerPoint file
- ❑ Look for missing items from charts, such as legends and axis titles, which sometimes disappear due to incorrect object reordering that can result from the tagging process for accessibility
- ❑ If you do find issues that you're not able to fix, a communications or publishing specialist at your organization may be able to help. Or, you can contact [VTAMR@ORAU.org](mailto:VTAMR@ORAU.org) to help troubleshoot the PDF conversion.



# Submitting Your Presentation

- ❑ You must submit your presentation files to ORISE no later than **May 14, 2021.**
  
- ❑ Submit your presentation to ORISE by sending an email with the following items to [VTAMR@ORAU.org](mailto:VTAMR@ORAU.org):
  - Your PowerPoint presentation file (.ppt or .pptx)
  - The PDF version of your PowerPoint presentation (.pdf)
  - Any changes to title or presenter. Title changes must be approved in advance by your VTO Technology Manager.
  
- ❑ If your presentation files are too large to submit through email, request an alternate delivery method by emailing [VTAMR@ORAU.org](mailto:VTAMR@ORAU.org)

# Oral Presentations

- Plan to present virtually via Zoom.
- Each session will have a moderator to enforce time limits and facilitate Q&A. Your mic will be muted once you have reached your time limit.

# Poster Presentations

- Poster presentations are **due 5/14**.
- Poster presenters are encouraged to format all content as one poster, rather than a complete slide deck.
- Poster presentations must be recorded and will be available on demand during AMR.
  - Your poster presentation recording should be no longer than 5 minutes.
  - **For reviewed posters, live Q&A will occur Friday, June 25, 2021**. Details will be provided in advance of the meeting.

# Oral Presentation Time Limits

- Your oral presentation will be either 15 minutes or 30 minutes in length as indicated on your invitation-to-present email from ORAU.
  - For **30-minute** presentations:
    - Oral presenters will be allowed 20 minutes for the prepared presentation and updates and 10 minutes for questions
    - Oral presentations should contain a **maximum of 15-20 presented slides.**
  - For **15-minute** presentations:
    - Oral presenters will be allowed 10 minutes for the prepared presentation and updates and 5 minutes for questions
    - Oral presentations should contain a **maximum of 8 - 10 presented slides.**
- **Time limits will be strictly enforced.**

# Additional Information

- A PDF version of the presentation slides will be available for attendees to download from the VTO AMR website just before the meeting. This PDF will not include PowerPoint animations, videos, or Reviewer-Only slides.

# Late Information Addition

- Information and research updates that become available following the submission of the presentation but before the AMR may be supplied verbally at the time of the oral or poster presentation.
- **No extensions will be granted for presentation submission.**
- Any additional information must still adhere to the time limitations.

# R&D Evaluation Criteria

All R&D presentations (oral and poster) follow the same content and design guidelines for reviewer scoring.

- **Relevance** **20%**
- **Approach** **20%**
- **Technical Accomplishments and Progress** **40%**
- **Collaborations and Coordination with Other Institutions** **10%**
- **Proposed Future Research** **10%**
  
- **Resources:** Reviewers will provide a qualitative evaluation of whether the project's resources are sufficient to achieve the stated milestones in a timely fashion.

**Consider these criteria and weights when creating your presentation!**

# Slide Titles

Except for the mandatory Title, Overview, and Summary slides, **all slide titles and headings should relate directly to the evaluation criteria!**

# Key Results

**The key take-home message for each results slide should be communicated as a banner, header, or bullet (see some examples on p. 44 and 51).**



# Instructions for Specific Slides

- The following guidelines provide specific information on mandatory slides and the type of information expected within the criteria guidelines. These instructions apply to both poster and oral presentations.
- **Your presentation should include:**
  - **Title Slide** (mandatory)
  - **Overview Slide** (mandatory)
  - **Review Criterion Slides** (mandatory, one or more slides as appropriate for each review criterion)
  - **Summary Slide** (mandatory)
  - **Technical Back-Up slides** (optional)
  - **Reviewer-Only slides** (optional).
- **The following slides include:**

**Instruction**

(Guidance for constructing the specific slides and sections)

**Example Slide**

(Examples are from previous AMR presentations)

# Title Slide

## □ Include:

- project title
- name of the principal investigator
- name of the presenter if different from the principal investigator
- organization
- project ID# (which ORAU will provide to you)
- Statement: “This presentation does not contain any proprietary, confidential, or otherwise restricted information.”

Instruction for all oral  
and poster  
presentations, unless  
otherwise noted

# 2021 DOE Vehicle Technologies Office Annual Merit Review Presentation (replace with your title)

P. I. Name (always include)

Presenter Name (if not the P.I.)

Organization

Date

Project ID #  
(this will be  
provided to you)

# Title Slide Examples



## ENABLING HIGH-ENERGY/HIGH-VOLTAGE LITHIUM-ION CELLS FOR TRANSPORTATION: PROJECT COMPLETION HIGHLIGHTS, PART 1

Project ID: BAT252

**JASON R. CROY**

Argonne National Laboratory  
June 11, 2019

2019 DOE Vehicle Technologies Office Annual Merit Review

This presentation does not contain any proprietary, confidential, or otherwise restricted information

## Consequence-Driven Cybersecurity for High-Power Charging Infrastructure

PI: Barney Carlson  
Idaho National Laboratory

June 13, 2017

DOE Vehicle Technologies Program Annual Merit Review  
INL/MIS-19-53414

Project ID: ELT199

This presentation does not contain any proprietary, or otherwise restricted information

Project ID# eems057  
Pillar(s): Urban Science

U.S. DEPARTMENT OF ENERGY  
**SMARTMOBILITY**  
Systems and Modeling for Accelerated Research in Transportation

## Urban Traveler – Changes and Impacts: Mobility Energy Productivity (MEP) Metric

Venu Garikapati, NREL  
DOE Vehicle Technologies Office  
2019 Vehicle Technologies Office Annual Merit Review  
June 11, 2019



THIS PRESENTATION DOES NOT CONTAIN ANY PROPRIETARY, CONFIDENTIAL, OR OTHERWISE RESTRICTED INFORMATION

# Mandatory Overview Slide

- ❑ Please prepare an Overview slide formatted and containing the information per the following slide:
  - Timeline (please confirm dates with your DOE HQ/NETL manager(s))
  - Budget (please confirm values with your DOE HQ/NETL manager(s))
  - Barriers (please list up to three technical barriers and technical targets from the most recent U.S. DRIVE Roadmap addressed by your project to be found at:  
<https://www.energy.gov/eere/vehicles/us-drive-partnership-plan-roadmaps-and-accomplishments>. MAT presenters should use the Light-Duty Workshop Final Report at [https://www1.eere.energy.gov/vehiclesandfuels/pdfs/wr\\_ldvehicles.pdf](https://www1.eere.energy.gov/vehiclesandfuels/pdfs/wr_ldvehicles.pdf) as their guide. If you don't see a report on your subject matter, please contact the relevant Technology Manager.
  - Partners.

# Overview

## Timeline

- Project start date
- Project end date
- Percent complete

## Budget

- Total project funding
  - DOE share
  - Contractor share
- Funding for FY 2020
- Funding for FY 2021 (if available)

## Barriers and Technical Targets

- Barriers addressed
  - List up to three technical barriers and technical targets from the most recent U.S. DRIVE Roadmap relevant to your project. For a list of roadmaps by subprogram, please see the link below:  
<https://www.energy.gov/eere/vehicles/us-drive-partnership-plan-roadmaps-and-accomplishments>
  - If you don't see a report on your subject matter, please contact the relevant Technology Manager.

## Partners

- Interactions/collaborations
- Project lead

# Overview Slide Examples

## OVERVIEW

### TIMELINE

- Start: October 2017
- End: September 2020
- 50% complete

### BUDGET

- Total project funding
- \$6M / 3 years
- \$2M per year / 3 Labs

### PARTNERS

- CalTrans Connected Corridors
- HERE Technologies

### BARRIERS

- Metropolitan scale networks are too complex to model in reasonable compute time.
- Sensors for capturing dynamics provide limited view and are difficult to mine for relevant information.
- Optimization of energy, travel time and mobility across complex networks has yet to be accomplished for real-world metropolitan scale networks.

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## OVERVIEW

### Timeline

- Project start: October 2018
- Project end: September 2021
- Percent complete: ~15%

### Barriers

- Recycling and Sustainability
  - Cost to recycle is currently 5-15% of battery cost
  - Material shortage (Li, Co, and Ni)
  - Varying chemistries result in variable backend value

### Budget

Year 1	\$4,615k
Argonne	\$2650k
NREL	\$965k
ORNL	\$550k
UCSD	\$150k
WPI	\$150k
MTU	\$150k

### Partners

- Argonne National Laboratory
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory
- University of California, San Diego
- Worcester Polytechnic Institute
- Michigan Technological University



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## Overview



### Timeline

- ▶ Start date: Sept 2017
- ▶ Project end date: Dec 2019
- ▶ Percent complete: 70%

### Barriers

- ▶ Need Increased Efficiency – bring power density above 5 kW/L
- ▶ “Reduction in the volume of the components is necessary to enable electric traction drive systems to fit within the increasingly smaller spaces available on the vehicle. **Motor volume reduction is limited by the flux density capacities of materials used in current electric steels and electrical conductivity limitations of copper windings**”<sup>1</sup>
- ▶ Need higher conductivity electrical conductors

### Budget

- ▶ Total project funding: \$1.15M
  - DOE: \$600,000
  - Industrial cost share: \$550,000
- ▶ Future Funds Anticipated: \$ 0

### Partners

- ▶ CRADA with General Motors Research and Development
- ▶ Project lead: PNNL



<sup>1</sup>U.S. DRIVE Electrical and Electronics Technical Team Roadmap October 2017  
<https://www.energy.gov/eere/vehicles/us-drive-partnership-plan-roadmaps-and-accomplishments>

# Relevance

- ❑ Relevance counts for 20% of your total project score.
- ❑ The title of these slides should make it clear that they are your project's **Relevance**.
- ❑ Information to include:
  - Describe the objective of your project and what you were to achieve over the past year in the work covered by your presentation
  - Clearly show how your project relates to the pertinent VTO subprogram area and how it will achieve the goals of that area (refer to the Annual Progress Report goals at <https://www.energy.gov/eere/vehicles/annual-progress-reports>)
  - Explain how your project will be relevant to
    - Reduction of energy costs
    - Increased energy security
    - Clean energy technology to move people and goods.
  - Describe the impact of your project on addressing the barriers identified in the Overview slide and other specific targets and milestones.

*You may verbally elaborate on project relevance in addition to what's on your slide.*



# Relevance

## Impact

Polymer electrolytes offer increased stability in lithium batteries in comparison to liquid electrolytes. We aim to synthesize new electrolytes that simultaneously have high transport properties and have greater stability against lithium metal for next-generation batteries.

## Objectives

- Develop new polymer composite electrolytes to enable lithium metal anodes.
- Identify failure modes at lithium metal anodes.
- Fundamental studies of the lithium metal/electrolyte interface.

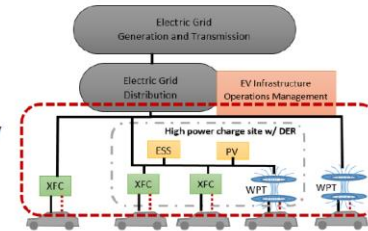


2

# Relevance Slide Examples

## Relevance

- Reduce risks associated with potential vulnerabilities for high power EV charging infrastructure leading to high consequence events (HCE)
  - Public Safety
  - Impact to the electric grid
  - Hardware damage
  - Denial of service
  - Data theft or alteration
- With enough time & effort, nearly any connected system can be accessed or compromised



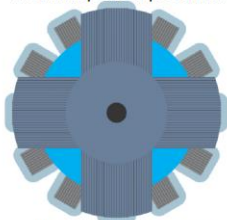
## Objective

- Determine high consequence events (HCE)
- Prioritize HCEs to guide future research efforts
  - Based on impact severity & cyber manipulation complexity
- Develop mitigation strategies and solutions
- Feedback solutions, information, and lessons learned to industry

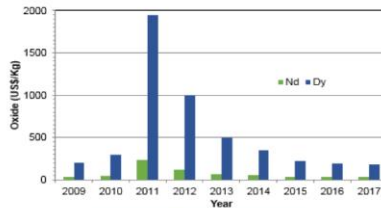
3

## 3 Relevance

- To meet 2025 goals for enhanced peak power (100 kW), specific power (50kW/L), and reduced cost (3.3 \$/kW) in a motor that operates at > 20,000 rpm, improved soft magnetic materials must be developed
- Improved soft magnetic materials will enable high performance non-rare-earth motors
- Replacement of permanent magnets with soft magnet materials highlighted in Electrical and Electronics Technical Team (EETT) Roadmap as a potential R&D pathway for meeting 2025 targets



Homopolar motor design (courtesy of Scott Sudhoff at Purdue) that doesn't require permanent magnets



As seen in Oct. 2017 EETT Roadmap

## Relevance

### Carbon - Copper Composites

- ▶ Fully dense Cu-C Composites have been made that show conductivity better than pure copper at elevated temperature
- ▶ Carbon is immiscible with copper so the effort is to see what kind of process can be used to make the composite and..
- ▶ if it actually increases conductivity

#### Forms of Carbon

- ▶ Graphite
- ▶ Reduced Graphene Oxide
- ▶ Graphene
- ▶ Single and Double Wall Carbon Nanotubes
- metallic or covalent

#### Possible manufacturing Process

- ▶ Layered Structures (PVD-CVD- other thin film methods)
- ▶ Super saturated solutions from ball milling or Magnetron Sputtering
- ▶ Bulk Composites from melt solidification Processes
- ▶ Covetic processing (melt solidification in a magnetic field?)
- ▶ Hot Extrusion

To date, few **bulk** methods have been successful at demonstrating increased conductivity

# Milestones

- ❑ Milestones may be presented in a separate slide directly before the Approach section or included as part of the Approach section.
- ❑ Include milestones and go/no-go decision points for FY 2021 and FY 2022.

## Milestones

Month/Year	Description of Milestone or Go/No-Go Decision	Status	Lab
March 2019	Report on potential to use AFIDA to quantify phi-sensitivity for three fuels showing phi-sensitivity in published engine combustion studies	Complete	NREL
June 2019	Quantify the effect of blending acetate esters into E10 and BOB on the RVP of the finished fuel	On Target	PNNL
March 2019	Investigate the potential to use the flow reactor for observation of shifts in autoignition mechanism with phi for phi-sensitive fuels, including results of kinetic simulations	Complete	NREL
September 2019	Using data from Foong and Kolodziej, relate concentration-dependent oxygenate clustering in two and three-component reference fuels to effects on engine performance properties, specifically, RON and MON, as well as HOV measurements from NREL	On Target	PNNL

AFIDA: Advanced Fuel Ignition Delay Analyzer  
BOB: blendstock for oxygenate blending  
MON: motor octane number  
RON: research octane number  
RVP: Reid vapor pressure

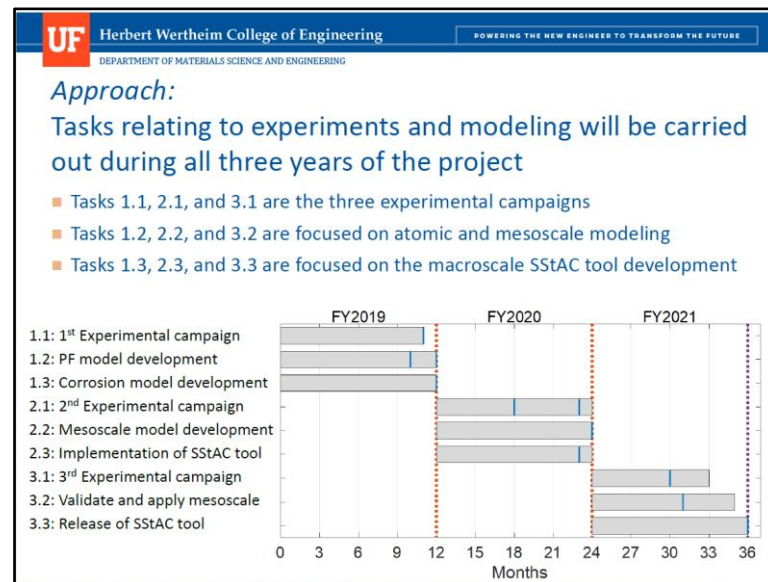
NREL: National Renewable Energy Laboratory  
PNNL: Pacific Northwest National Laboratory

## Milestones

Time	Description ( <i>status</i> )
Dec., 2018	Complete <i>in situ</i> studies of the local cationic ordering during solid-state synthesis of high-Ni NMC layered oxides from the hydroxide counterparts. ( <i>complete</i> )
March, 2019	Identify the roles of Co/Mn substitution in tuning Li/Ni mixing in high-Ni NMC layered oxides. ( <i>complete</i> )
June, 2019	Develop procedures for <i>in situ</i> probing and synthetic control of local structural ordering in compositionally heterogeneous NMC oxides. ( <i>on-schedule</i> )
Sept., 2019	Develop <i>in situ</i> techniques for studying surface reconstruction during synthesis of high-Ni NMC oxides. ( <i>on-schedule</i> )
Sept., 2019	Complete structural/electrochemical characterization of the synthesized high-Ni NMC layered oxides. ( <i>on schedule</i> )

## MILESTONES

Month/Year	Description of Milestone or Go/No-Go Decision	Status
June 2018	Conference paper, "Quantifying the Mobility and Energy Benefits of Automated Mobility Districts Using Microscopic Traffic Simulation," presented at the American Society of Civil Engineers – International Conference on Transportation and Development conference held in Pittsburgh, PA	Complete
September 2018	Exercise the AMD modeling toolkit for a real-world deployment	Complete (AMD Simulation for Greenville, SC)
February 2019	Journal paper, "Route and Fleet Size Optimization in an Automated Mobility District: Serving On-demand Mobility with Automated Electric Shuttles," submitted to <i>Transportation Research – Part C</i>	Complete
August 2019	Integration of Mode Choice module into AMD toolkit Integration of Optimization module into AMD toolkit	On Schedule



# Approach

- ❑ Approach counts for 20% of your total project score.
- ❑ **The title of your slides should make it clear that they are your project's **Approach**.**
- ❑ Describe overall Technical Approach:
  - Emphasize unique aspects of your work and de-emphasize discussion of equipment used
  - Discuss how your work addresses the project's technical barriers
  - Describe how your project is integrated with other research or deployment projects within the pertinent VTO subprogram
  - Use simple statements so that scientists and engineers, not experts in your area, can readily understand the explanation of your approach.
- ❑ Include the planned milestones and go/no-go decision points for FY 2021 and FY 2022 and current status toward them (if not shown in a separate Milestone slide).

## APPROACH

BYU

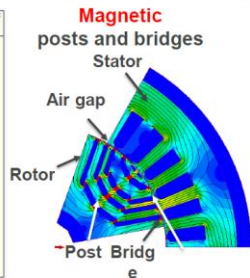
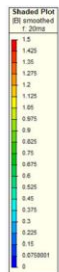
We propose to enable improved electrode manufacturing processes by rapid feedback on transport and mechanical problems associated with the microstructural arrangement of particles. A range of new experimental and modeling tools have been developed to measure and predict *localized* properties.

- Construct novel micro-N-line surface probes that can sample local conductivity of intact battery electrodes
- Experimentally compare tradeoffs of and effects on electronic and ionic transport (collaborations with NREL, ANL, Navitas, K2, others)
- Construct a first-principles particle-dynamics model that can predict electrode microstructure and conductive pathways
- Construct a laser-based acoustic probe for rapidly determining mechanical properties of electrode films

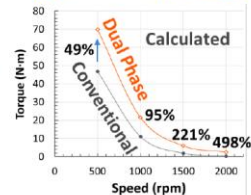
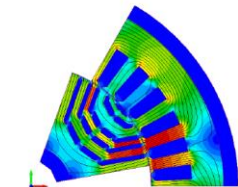
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## Approach: Strategy

Locally control the magnetic and mechanical properties of motor laminates by material alloying and processing



Non-magnetic posts and bridges



- Decrease magnetic flux leakage
- Enhance mechanical integrity
- Improve machine performance

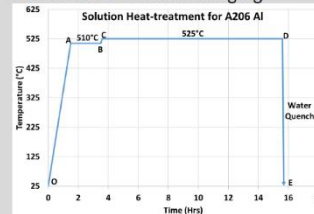


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## Approach

### Heat-treatment Development

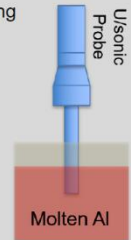
- A206 Al alloy: 4.6% copper (Cu) – 0.35% manganese (Mn) – 0.25% magnesium (Mg) – 0.22% titanium (Ti)
- PNNL proprietary
- Goal: Shorten solution/aging



### Molten Al Process Development

- A356 Al alloy: 6.5-7.5% (silicon) Si, 0.25-0.45% Mg, iron (Fe)...
  - 0.2% Fe ("primary alloy")
  - 0.6% Fe ("secondary alloy")
- Ultrasonic melt processing

- Goal: Refine the microstructure for finer intermetallics and lower dendrite arm spacing to improve ductility and more uniform properties throughout the casting



May 21, 2019 4

# Technical Accomplishments and Progress

- ❑ Technical Accomplishments and Progress count for 40% of your total project score.
- ❑ The title of these slides should make it clear that they are your project's **Technical Accomplishments and Progress**.
- ❑ Each slide should include a summary “take-home” message, especially those that contain data.
- ❑ **Describe the most important technical accomplishments achieved during the reporting period and their significance.** Specifically, address last year’s reviewer comments regarding technical accomplishments and progress as well as progress to date for new projects.
- ❑ Include relevant data to support your accomplishments.
- ❑ Relate the accomplishments to project milestones, barriers, objectives, and technical targets.
- ❑ Benchmark the progress versus FY 2020 results, if applicable.

# Technical Accomplishments and Progress - Continued

- ❑ Include no more than one slide on previous accomplishments and CLEARLY indicate work previously presented versus new work!
- ❑ To assist the reviewers evaluating your work, please include bullet comments of the key points on each slide.
- ❑ Include sufficient slides to explain what was done leading to the technical accomplishments.
  - However, please limit your slides to the time you have available – 10 minutes for 15-minute presentations and 20 minutes for 30-minute presentations – time limits will be STRICTLY enforced!
- ❑ Though your presentation will be in color, it is best to choose colors and data symbols that can be easily distinguished in black and white for those reviewers using hardcopies.

Changes in reaction chemistry with phi observed, but higher pressures required to observe phi-sensitivity relevant to engine conditions

- PRF80 demonstrated phi-sensitivity in HCCI engine studies
- PRF80 was examined in atmospheric pressure flow reactor at 600 K – 1000 K and phi of 0.25, 0.5, and 1
- Small changes in reactivity with phi were observed, however higher pressures are required to observe low-temperature and intermediate-temperature reactions believed to be related to phi-sensitivity
- Reactor modifications are underway to increase pressure to the 5 to 10 bar range and to allow more precise quantification of formaldehyde
- Future improvements proposed to achieve even higher pressures

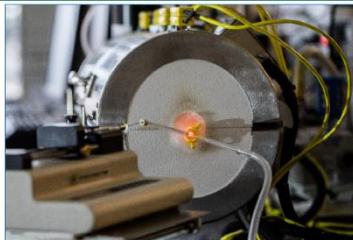


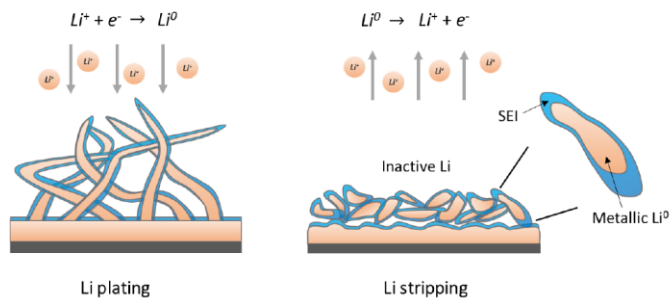
Photo by Werner Slocum, NREL 56025

**Impact:** With modifications to achieve higher pressure, flow reactor experiments can be utilized to identify and quantitate key species in autoignition mechanisms that can explain phi-sensitivity

HCCI: homogeneous charge compression ignition

## Accomplishment to Date FY 19

### Electrochemical reactions of Li plating/stripping, dendrite formation and inactive Li formation



❑ In a Li metal battery, during the plating,  $Li^+$  deposits on the fresh Li. In commercial carbonate-based electrolytes, Li deposits exhibit whisker-like morphology.

❑ If the dissolution occurs firstly on the roots of the Li whiskers, the top parts will disconnect from the electronic conductive network and thus become electrochemically inactive, forming inactive Li.

12

C. Fang, X. Wang, Y.S. Meng, Trends in Chemistry, 2019, in print



## Accomplishments Cummins Energy Recovery Drive (CERD)



- Hardware integration confirmed
- Validation of controls systems integration
- Correlation of simulation results to test data
- Transmission shifting validated
- Great collaboration with ORNL!
- 3.4% fuel savings expected

Cummins | 10



# Responses to Previous Year Reviewers' Comments

- All VTO AMR reports are posted on the VTO website along with Annual Progress Reports at <https://www.energy.gov/eere/vehicles/annual-progress-reports>
- Last year's presentations can be found at: <https://www.energy.gov/eere/vehicles/annual-merit-review-presentations>.


**If your project was not reviewed last year, please indicate as such on the slide.**

# Reviewer Comment Slide Examples

## Prior AMR Comments/Questions

“It is not clear why single wide base tire was not selected for this program.”

- Current Market: 90% Dual
- Market Sensitivities
  - Highest Tire Life: Duals
  - Highest Retread Rate: Duals
  - Lowest Weight: Wide Base
- Tire Construction
  - Vastly Different
  - Not Transferrable
- Commercial Value > Weight Penalty



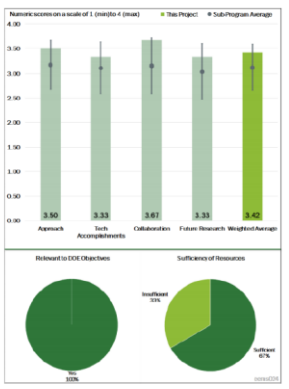
Duals vs. Wide Base

## Responses to Previous Year's Reviewers' Comments

► This is the first year that the project has been reviewed

## Responses to Previous Year Reviewers' Comments

- The TEEM project was not reviewed in 2018, but at the 2017 AMR. Two main concerns were:
- “validation and verification of the model was not discussed during the presentation and it was unclear to the reviewer whether this step is occurring or not”
  - Response: MA3T and MA3T-China have been calibrated to historical sales and price data. MA3T-MC inherits all calibration of MA3T and also calibration on share mobility PMT share. Validity of these models are achieved through peer reviews on the usefulness, transparency, consistency and logicity (Senge and Forrester, 1980)
- Alternative specific constants for both choice and choice category; how ASCs are specified for future
  - Response: Because adding an ASC for a choice category can be equivalent to adding a constant (may not be the same value) to all choices in that category. With this spirit, we chose to adjust ASCs for each choice to achieve the same modeling outcome. ASCs for the future are determined based on certain vehicle class-level assumptions. For example, all car choices' ASCs are assumed to converge to the same value in 2050, while all SUV choices' ASCs converges to the same value, but different from that for cars. Documentation are being prepared.
- The MA3T-MC work was reviewed in 2018 (review scores on the right). The project at 2018 AMR received overall positive assessments by reviewers. Almost all comments were neutral or positive. No concerns were raised.



## Response to Previous Year Reviewers' Comments

The reviewer complimented this project for having developed exceptional methods for better measuring/predicting fuel properties and generating valuable data for mechanism validation. The reviewer stated that the project could be significantly better if the flow reactor can be upgraded to be capable of operating at higher pressure, which is critical to validate reaction mechanisms at conditions closer in ICEs.

*We thank the reviewer for complimenting the progress of the project to date. We strongly agree that upgrading the flow reactor to operate at elevated pressures is an important task and have begun to take steps to increase our pressures to 5-10 atmospheres (atm). In addition, we are working on a white paper proposing to operate to even higher pressures of up to 50 atm.*

ICEs: internal combustion engines

# Collaboration and Coordination with Other Institutions

- ❑ Collaborations and Coordination with Other Institutions count for 10% of your total project score.
- ❑ The title of these slides should make it clear that they are your Collaborations and Coordination with Other Institutions.
- ❑ List your project collaborators, indicating:
  - Relationship (for example, prime, sub, etc.)
  - Industry, university, National Laboratory
  - Within or outside VTO
  - Extent of the collaboration.
- ❑ Describe the quality of collaborative relationships and their importance in achieving the project's objectives.

## 14 Collaboration



- Purdue University (Scott Sudoff) – Motor design, prototyping, and testing



- IIT – Design, construction, and dynamometer testing of 3 reduce power prototype machines



- ORNL – High-Fidelity Multiphysics Material Models for Electric Motors



- Ames – Additional expertise in magnetic material fabrication, processing, and characterization



- NREL – Advanced packaging, reliability, prognostics, thermal management

## Collaborations

- **Brookhaven National Lab** (*L. Wu, Y. Zhu, A. Kiss, J. Thieme, K. Chen, M. Ge, X. Xiao, W-K. Lee, E. Dooryhee*)
  - Synchrotron techniques/capabilities for characterization of cathodes
  - Advanced electron microscopy imaging and spectroscopy of cathodes
- **Argonne National Lab** (*Z. Chen, K. Amine Y-H. Shin, Y. Ren, C. Sun, D. Abraham, V. Srinivasan*)
  - Synthesis and characterization of high-Ni NMC
  - Characterization of the materials from the Materials Engineering Research Facility (MERF)
  - Modeling of the synthesis
- **Lawrence Berkeley National Lab** (*W. Sun, G. Ceder*)
  - Theoretical prediction of the phases/ordering in high-Ni NMC
  - Characterization of cathode materials
- **Oak Ridge National Lab** (*J. Nanda, A. Huq*)
  - Neutron characterization of high-Ni NMC
- **Stony Brook U.** (*E. Takeuchi, K. Chen*)
  - Synthesis and characterization of high-capacity cathodes

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## Collaboration and Coordination

- **OSU's Impulse Manufacturing Lab, Fontana Corrosion Center, CDME:** Facilities and expertise for impact welding, process development, standard corrosion testing at coupon and subcomponent level in addition to program management
- **Magna (Sub):** CAD, CAE, prototype build and testing
- **Coldwater Machine Company (Sub):** equipment builder and system integrator
- **PNNL:** Numerical simulation of impact welding process, interfacial wavy pattern and jetting, and mechanical performance of the welded coupons
- **Ashland:** Supplies structural adhesives for galvanic corrosion protection. Also provides in-house testing
- **Arconic:** Supplies 5xxx and 6xxx sheets for screening tests and prototype build
- **Hydro:** Supplies 6xxx and 7xxx grade aluminum extrusions for possible chassis and body side applications



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## Partnerships/Collaborations

	Vehicle Development, Vehicle Level Supervisory Controls
	Engine Development, Engine Management Systems
	Powertrain Development, Advanced Predictive Features, Program Administration
	Electrified Powertrain, Transmission, Valvetrain and Air Management Systems Development
	Powertrain Analysis, Battery Controls, Engine Development
	Drive Cycle Development Thermal Management
	Drive Cycle Development Tech Market Acceptance Advisory
	Waste Heat Recovery Integration
	Axle Integration
	Tire Development

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# Remaining Challenges and Barriers

- ❑ Highlight the key remaining challenges and barriers to meeting the project objectives.
- ❑ The remaining challenges and barriers should provide justification and support for the future plans in the following slide.

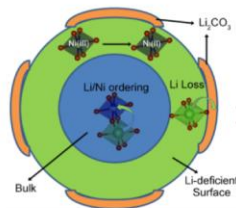
## Remaining Challenges and Barriers

- Gathering information on proprietary motor-integrated power electronics and thermal management solutions (not readily available or open source) for evaluation and comparison
- Identifying driveline fluids suitable for direct cooling of high-voltage (400V-1,200V) power electronics
- Potential need for quantifying electrical (dielectric) properties at high voltages for selected candidate fluids => requiring development of additional in-house fluid characterization capabilities or identifying external providers of similar services

MEL | 14

## Remaining Challenges and Barriers

- **Main barriers:** Capacity fading has been the main obstacle to realization of high-Ni NMCs with true commercial potential for lithium-ion batteries.
- **Technical challenges:** Synthesis of specific cathode materials by design has proven difficult due to the complexity of the reaction involved in chemical synthesis, and the high sensitivity of the phases, stoichiometry and morphology to synthesis parameters (*precursor, sintering temperature, atmosphere, heating/cooling rates...*)
- Synthesis of high-Ni NMCs is even more challenging, due to the demanding requirement on the control of both cationic ordering in the bulk and surface/interfaces (*as illustrated*).



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## REMAINING CHALLENGES AND BARRIERS

- Cavitation in multi-hole nozzles is significantly more complicated than in single-hole
  - Fuel "turns a corner"
  - Needle motion can generate complicated flows in sac
  - String cavitation can reach from hole-to-hole
  - Need measurements in multi-hole nozzles
- The link between cavitation and nozzle erosion is not well-understood
  - Need reliable predictions of cavitation, AND models of erosion
  - Models are being developed, but fundamental data is lacking.
- Flash-boiling and spray collapse can cause sudden, extreme changes in the fuel/air mixture
  - This cannot be reliably predicted, need systematic measurements
- Sprays impinging on walls can cause emissions challenges
  - Current wall-wetting models rely on 20-year-old measurements of simplified systems, can't accurately predict splashing, evaporation, spreading

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Argonne  
National Laboratory

# Proposed Future Research

- ❑ Proposed Future Research counts for 10% of your total project score.
- ❑ The title of this slide should make it clear that the slide shows your Proposed Future Research!
- ❑ Explain what you plan to do during the rest of this year (FY 2021) and next year (FY 2022). Provide justification for future plans.
- ❑ Add the statement to all slides with future-looking statements, “Any proposed future work is subject to change based on funding levels.”
- ❑ Be as specific as possible; avoid blanket statements.
- ❑ Highlight upcoming key milestones.
- ❑ Address how you will deal with any future decision points during that time and any remaining issues or barriers, including any alternative development pathways under consideration to mitigate risk of not achieving milestones.

## PROPOSED FUTURE WORK IN FY2019 AND FY2020

- Heavy Duty Injection
  - 3D Measurements of cavitation in multi-hole injector
  - Non-destructive x-ray measurements of geometry will be used to track nozzle erosion over time
    - Collaboration with Kolodziej, Caterpillar
    - Collaboration with Som, Magnotti
    - Searching for collaboration with industry partner
    - Data will be used to support development of erosion models
- Light Duty Injection
  - Will transition to the Light Duty Combustion Consortium
  - Flash boiling sprays – explore parametric variations
  - Measurements of spray collapse
  - Sprays impinging on surfaces
    - X-rays can quantify the density distribution, surface area, SMD
    - Before and after spray impact
    - Effect of wall temperature (cold start), roughness

Any proposed future work is subject to change based on funding levels



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## Proposed Future Research

### Key Challenges

- Demonstration of scalability for industry adoption.
  - Optimizing core losses while maintaining manufacturability
- Casting at such high temperature requires advanced cooling technology for copper wheel.



Verify material manufacturability by coin ring punch test

### Future work

- Improve coating, stamping and stacking of thin laminates.
  - ✓ Scalability
  - ✓ Cost



Perfect Fe – 6.5 wt.% Si produced by large melt spinner

Any proposed future work is subject to change based on funding levels.

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## Proposed Future Research

### FY19: Model Validation: Single Cylinder Prototype

- Optimize prototype parameters
- Detailed design of prototype
- Fabricate prototype
- Dynamometer testing and model validation
- Develop system control strategy

### FY20: Performance Demonstration: Multi-Cylinder Prototype

- Optimize multi-cylinder prototype
- Detailed design: include displacement actuation
- Fabricate prototype
- Hardware-in-loop: controller evaluation and performance demonstration

Any proposed future work is subject to change based on funding levels



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## Future/On-going Work (FY19-20)

- Continue working on synthetic design of high-Ni NMC, with focuses on
  - impact of synthesis conditions on surface/interfaces and the electrochemical properties (See preliminary results in *Backup Slide 23*)
  - local cationic inter-diffusion/ordering in individual particles with compositional inhomogeneity (as demonstrated in *Backup Slide 24*)
- Develop new *in situ* techniques and capabilities, specialized for probing synthesis reaction under real conditions
  - simultaneous or combined X-ray scattering/spectroscopy/imaging for multimodal characterization
  - techniques capable of high spatial resolution and/or high sensitivity to local structural ordering at surface/interfaces
- Apply the established approaches to synthetic design of
  - NMC811 and those with higher Ni content
  - low-Co/Co-free cathode materials

Any proposed future work is subject to change based on funding levels

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# Mandatory Summary Slide

- ❑ Summarize the key points you wish the reviewers and the audience to take away from your presentation.
- ❑ For those projects that are working toward specific technical targets, include a Summary Table summarizing key technical results to date in FY 2021 compared to FY 2020 results and the technical targets.

## Summary

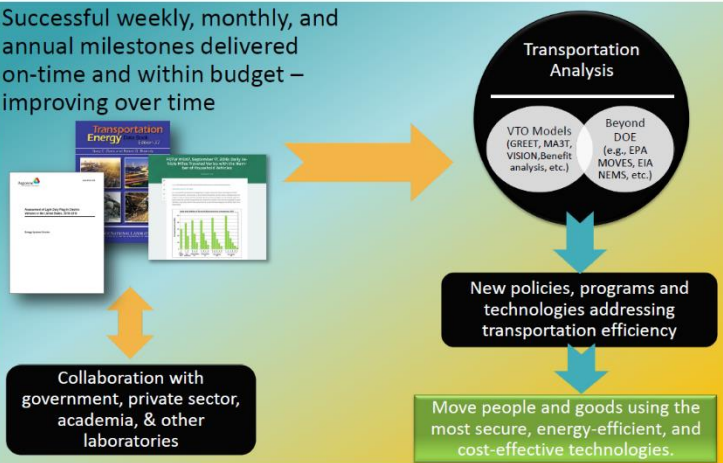
- Modifying traditional planar flow casting methods to simultaneously achieve disordered phase with larger grain size for the 6.5% Si steel.
  - Reduce core losses yet maintain formability
- Demonstrated planar flow casting system with model alloy
  - continuous ribbons with 10 mm width were obtained.
- Developing 25 mm wide ribbon of 6.5% Si steel
  - Melting point is ~300 °C higher than the model alloy



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## Summary

Successful weekly, monthly, and annual milestones delivered on-time and within budget – improving over time



22 OAK RIDGE National Laboratory

## Summary



### Accomplishments

- ✓ We have used Shear-assisted extrusion and processing (ShAPE) to fabricate Copper-carbon composite wire with 0.1" diameter
- ✓ We have developed extrusion tools and dies for producing Copper-carbon composites .
- ✓ We are developing fully dense extrudates by conducting parametric studies of the process parameters

### Technical highlights

- ✓ Mixed and densified copper and carbon powder to a solid puck and extruded copper-carbon composite wire with good integrity and properties
- ✓ We have seen a verifiable increase in conductivity as high as 3% over ICAS Copper
  - ✓ Wire manufacturers we have consulted consider this a significant increase

### Impact toward VTO Objectives

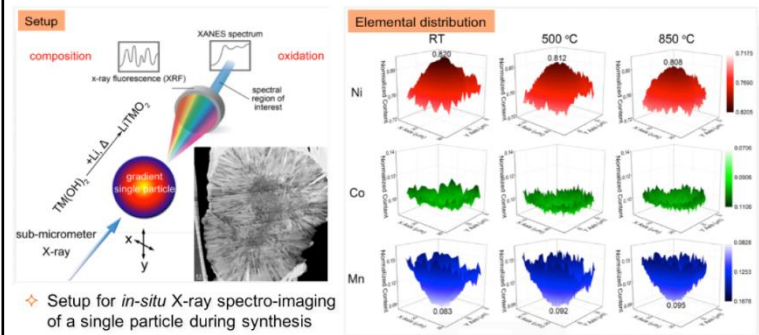
This project will leverage a new manufacturing process to manufacture high conductivity wire by an unconventional method involving high shear and plastic deformation. It could be disruptive to the way automotive traction drives are constructed, sized or powered. The high conductivity wire for stator winding could spill over into permanent magnet motor space where there are also strong incentives to improve motor performance.

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# Technical Back-Up Slides

(Note: please include a “divider” slide if you are including back-up technical slides [maximum of five]. These optional back-up technical slides will be available for your presentation and will be included in the web PDF files released to the public.)

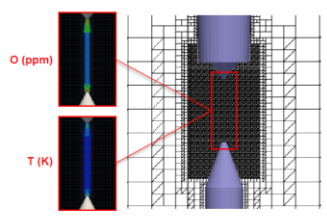
# Backup (3) *In situ* probing of inter-diffusion in high-Ni NMC during synthesis



- Setup for *in-situ* X-ray spectro-imaging of a single particle during synthesis
- Quantification of elemental inter-diffusion within a single particle
  - Fast inter-diffusion < 500 °C, comparable to that at high temperatures.

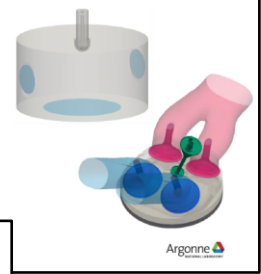
# TECHNICAL BACKUP SLIDES

## CONVERGE simulations setup



- ### LTP ignition in SNL calorimeter
- RANS modeling (RNG k-ε)
  - SAGE solver (well stirred reactor + multi-zone)
    - GRI MECH 3.0
  - T = 343K, p = 1.3 bar, φ = 1.0
  - Base 2.0 mm, AMR 0.25 mm, Embedding 0.0625 mm
  - Total cell count = 350k-550k (increase due to AMR)
  - Combined energy/O deposition from VIZGLOW

- ### PC ignition in SNL optical vessel and ANL single-cylinder engine
- RANS modeling (RNG k-ε)
  - SAGE solver (well stirred reactor + multi-zone)
    - Aramco Mechanism 1.3 (253 species, 1542 reactions) for C<sub>2</sub>H<sub>4</sub>
    - Co-Optima mechanism (122 species, 647 reactions) for Alkylate
  - T = 500K, p = 5 bar, φ = 1.0 (Sandia vessel)
  - 1500 rpm, nIMEP 3.2 bar, φ = 1 (Argonne single-cylinder)
  - Base 1.0 mm, AMR 0.5 mm, Embedding 0.125 mm
  - Ignition by thermal energy deposition (spherical source, 50 mJ)



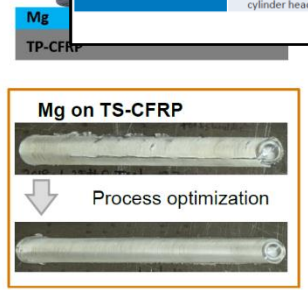
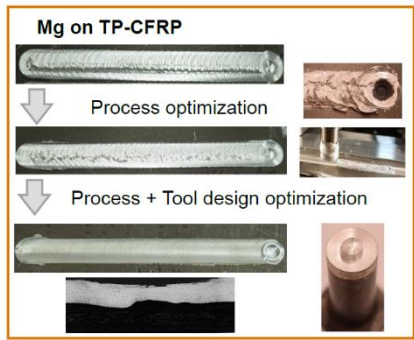
# Back-Up Slide Examples

## Experimental Parameters Across Labs

	ANL	NREL	ORNL	SNL
<b>Engine/Main-Chamber</b>				
No. cylinders	1	(chamber)	6	1
Displacement [l/cyl]	1.85	0.38 (chamber vol.)	2.13	2.34
Bore [mm]	130	100 (chamber diam.)	132	140
Squish height [mm]	0.8	40 (chamber length)		5.5
Bowl diameter [mm]	100	none (conical P/T and T/C port)		100
Bowl depth [mm]	26	none (conical P/T and T/C port)		15.5
Main-chamber fueling	Fumigation	Mass Flow Controller	Fumigation and/or DI	Fumigation and/or DI
<b>Initial Pre-Chamber</b>				
Volume [cc]	4.67	4.5	1.5 - 6.0	5.5 - 8.4
Number of holes	8		8	8
Hole diameter [mm]	1.6	1.6	1.2-1.5	1.6
Included angle [degrees]	130		120	130
Pre-chamber fueling	Check-valve	DI Bosch (Ford GDI part)		DI
Spark plug	M8 - NGK ER6HX	NGK ER6HX (Mini Rimfire can also be packaged)	M8 - Denso/NGK	
Ignition	Continuous	Cycles are user selectable	Continuous	
<b>Measurements</b>				
Exhaust emissions	Full exhaust gas analysis NO <sub>x</sub> , THC, CH <sub>4</sub> , CO, CO <sub>2</sub> , O <sub>2</sub> , and CO <sub>2</sub> (EGR)	NO <sub>x</sub> , CH <sub>4</sub> , CO <sub>2</sub> , CO, O <sub>2</sub> + detailed HC speciation	5 Gas Bench + CH <sub>4</sub> + FTIR (exhaust/EGR) + advance speciation /PM as needed	
Chamber pressures	Main and Pre	Main and Pre	Main and Pre	
Indicated efficiency	Yes	NA	Yes - all 6 cyl	
Brake efficiency	Limited (1-cyl setup)	NA	Yes	
Optical diagnostics	AVL VisioScope possible with cylinder head modification	No	No	

## FRICION STIR INTERLOCKING PROCESS DEVELOPMENT

➤ Stage 1: Mg-CFRP bead on plate (BoP)

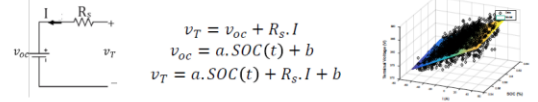


## Technical Backup Energy Consumption Measurements (Battery Electric test vehicle)

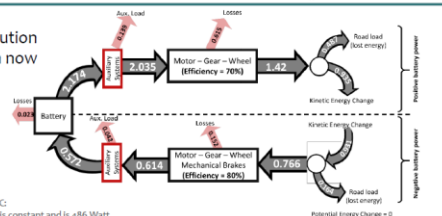
- Unlike our combustion test vehicle, the specification of the packets sent to the OBD port of our electric Nissan Leaf vehicle are not published by the vehicle manufacturer.
- Our OBD Logger App was extended to collect the battery's current, voltage, state-of-charge (SOC), and capacity via OBD port of the Nissan Leaf.

To estimate the resistive energy loss of the battery, we estimated the battery's internal resistance value using the collected OBD data.

The terminal voltage ( $v_T$ ), and charging/discharging current ( $I$ ) are available via OBD port. By linear regression\* we obtained  $R_s = 0.1 \text{ (ohm)}$ .



The estimated energy distribution (kWh) for our electric vehicle can now be plotted for each road test\*\*:



\* Assuming Open Circuit Voltage ( $v_{oc}$ ) is a linear function of SOC.  
 \*\* Assuming that the power consumed by the auxiliary systems is constant and is 486 Watt.

# Reviewer-Only Slides

These optional slides may be included in your submission, but will not be part of your oral presentation – they will be provided to reviewers only. **These optional slides will be removed from the presentation file and the web PDF files.)**

Precede these slides with a divider slide marked “Reviewer-Only Slides”

# Publications and Presentations

- List any publications and presentations that have resulted from work on this project.
- Use at least 12-point font.
- Please verify that the links in your slides are active.

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# Critical Assumptions and Issues

- ❑ Address three to five critical assumptions and/or problems affecting the outcome of your project. Briefly describe the problem as well as potential solutions, both within and beyond the scope of the project.
- ❑ Exclude funding issues.

Note: This slide is for the Reviewers only; it is not to be presented as part of your oral presentation. These Reviewer-Only slides will be included in the presentation file made available to Reviewers.

# Questions?

*Contact us by email:*  
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