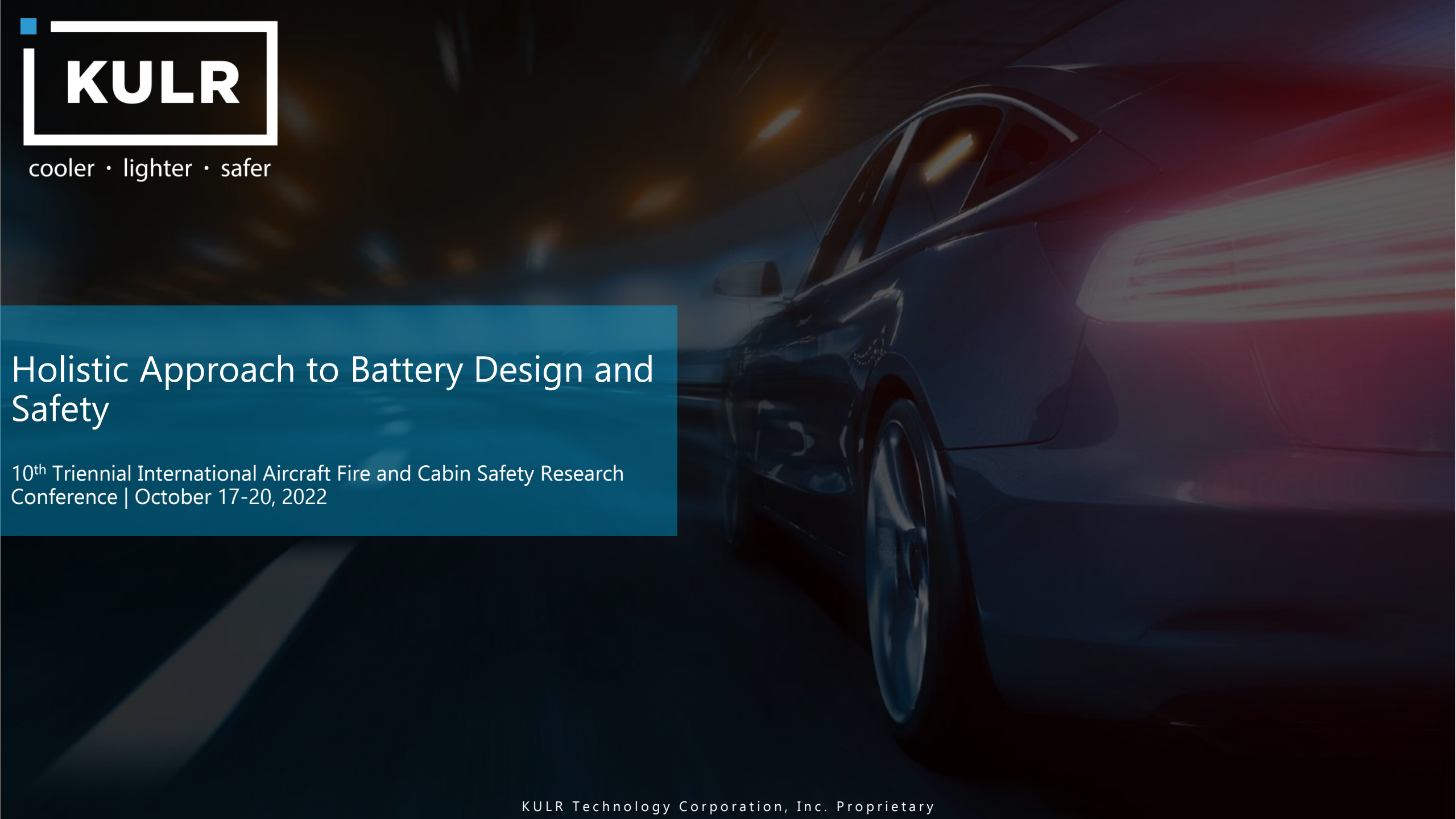

Holistic Approach to Battery Design and Safety

10th Triennial International Aircraft Fire and Cabin Safety Research Conference | October 17-20, 2022

KULR Technology Corporation, Inc. Proprietary

KULR's Mission

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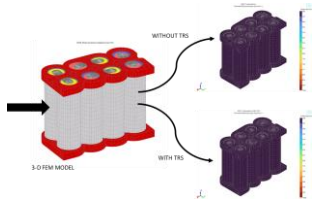
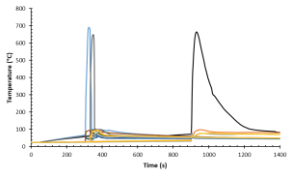
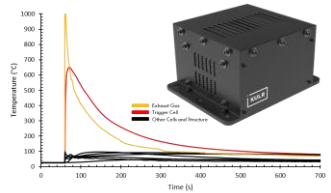
Developing Energy Management Platforms to Accelerate the Global Transition to Circular Electrification Economy

- Use less energy.
- Use energy more efficiently.
- Make energy consumption safer and cooler.
- Use less material to achieve these goals.
- Complete the circular economy through recycling.

Holistic Approach to Battery Safety Management







Cell Level Testing

Analysis Informed Design

Sensible Design Decisions

Pack Level Testing

System Level Testing

Real Time Monitoring

Transport and Recycling

Testing of Battery Storage and Transportation Solution

SafeCASE & SafeSLEEVE

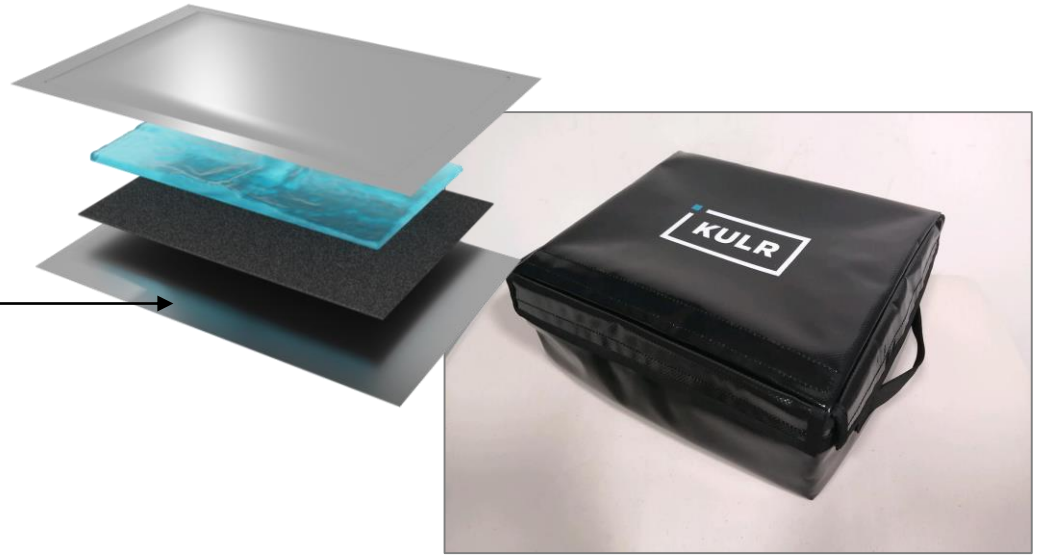
KULR's patent pending SafeCASE is a best-in-class passive propagation resistant (PPR) storage and transportation solution for Li-ion batteries:

- SafeCase is designed to mitigate thermal runaway, providing safe and sustainable storage and transportation for Li-ion cells and battery packs.
- DOT approved (21139, 21167, 21193) for transportation and rated up to 2.5 kWh per case.
- Utilizes KULR's patented Thermal Runaway Shield (TRS) technology.
- Foldable for compact storage and is constructed with safe, non-toxic, materials.

Sizes and housing material can be customized upon request.

Transportation and storage of Li-ion battery packs up to 2.5 kWh:

- Recycled EOL battery shipment – DOT Special Permit SP21139.
- Prototype battery shipment – DOT Special Permit SP21167.
- DDR battery shipment – DOT Special Permit SP21193.



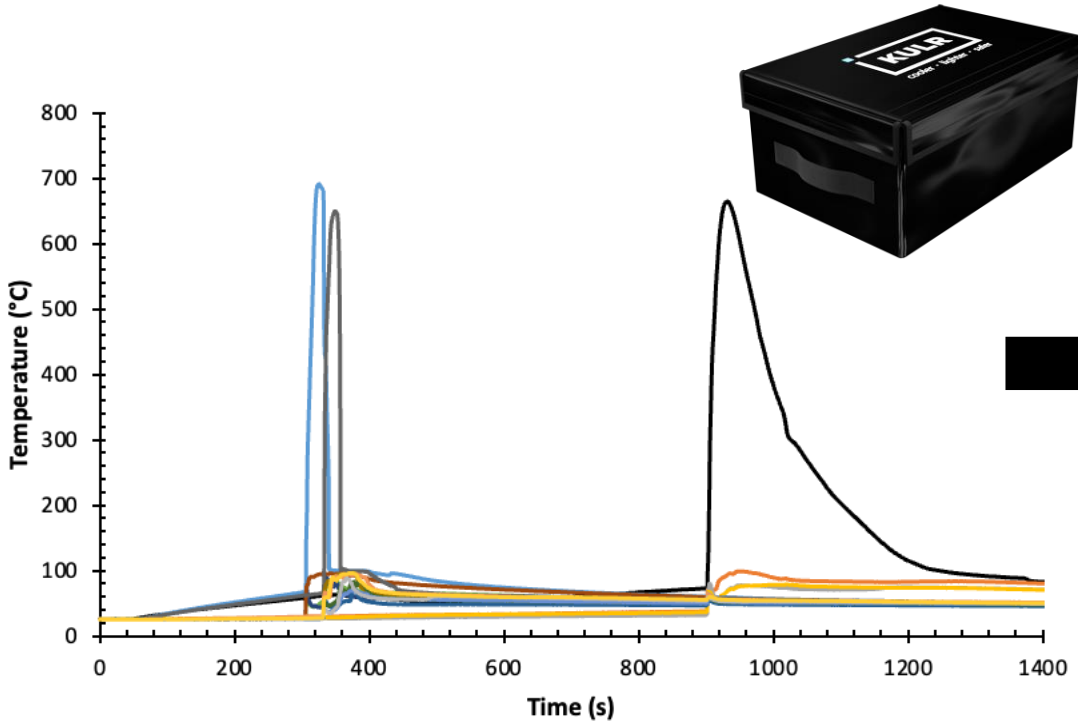
SafeCASE 2.5 kWh Capacity

Properties	
Exterior Dimension	18.0"W x 12.0" D x 8.0" H
Interior Dimension	17.5"W x 11.5"D x7.5"H
DOT Permitted	DOT (21139, 21167, 21193)
Capacity Rating	2.5 kWh

Applications

Testing of Battery Storage and Transportation System

SafeCASE & SafeSLEEVE



Evaluating Material Response to Thermal Runaway Ejecta

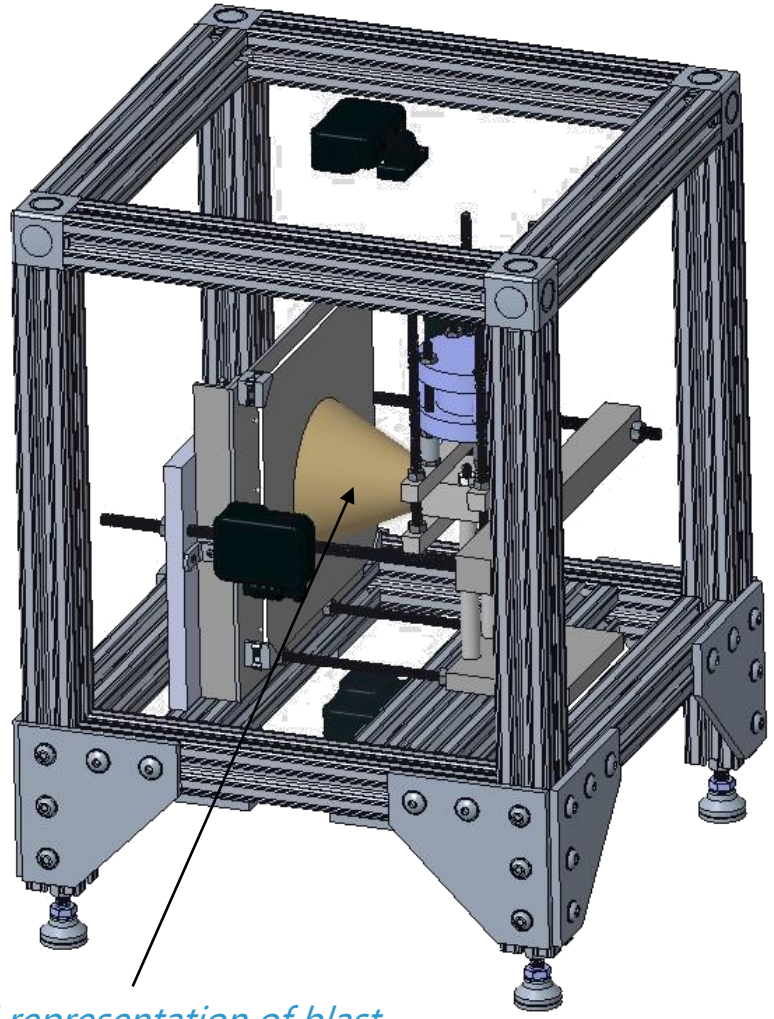
Impingement Zone Mapping

Expansion of SafeCASE product line protective capacity requires extensive testing to evaluate material performance:

- Specifically aiming to understand material protection against the blast effects in the impingement zone.
- Impingement zone = region impacted by the thermal runaway ejecta materials.

For this study we evaluate the expansion of the smaller version of SafeCASE, called SafeSLEEVE, to the 300 Wh range:

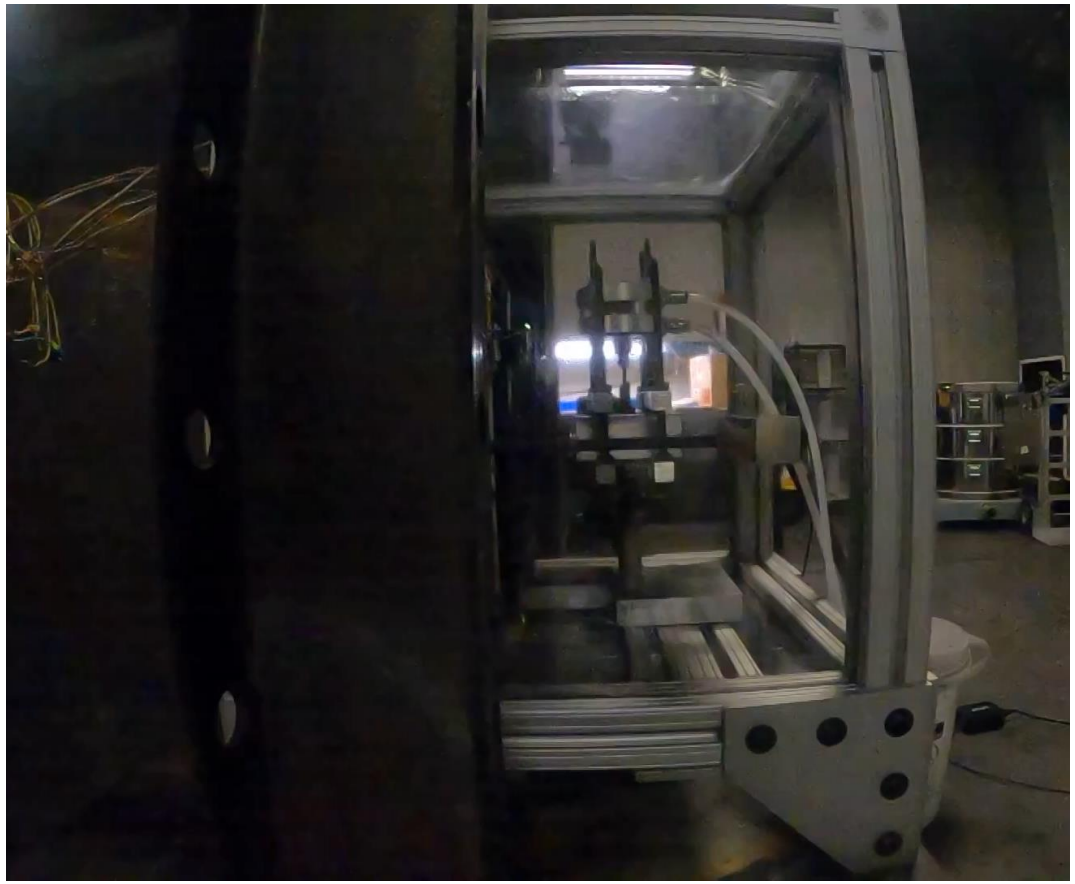
- Utilized KULR's **Impingement Zone Mapping (IZM)** capabilities combined with blast plate apparatus to study material response within tight impingement zone proximity (< ¼").
- Describe results here for Materials A, B, & C followed by a full-scale test results for best candidate material.
- Used nail penetration and LG 18650-MJ1 for thermal runaway heating.



Digital representation of blast zone.

Evaluating Material Response to Thermal Runaway Ejecta

Material A



Evaluating Material Response to Thermal Runaway Ejecta

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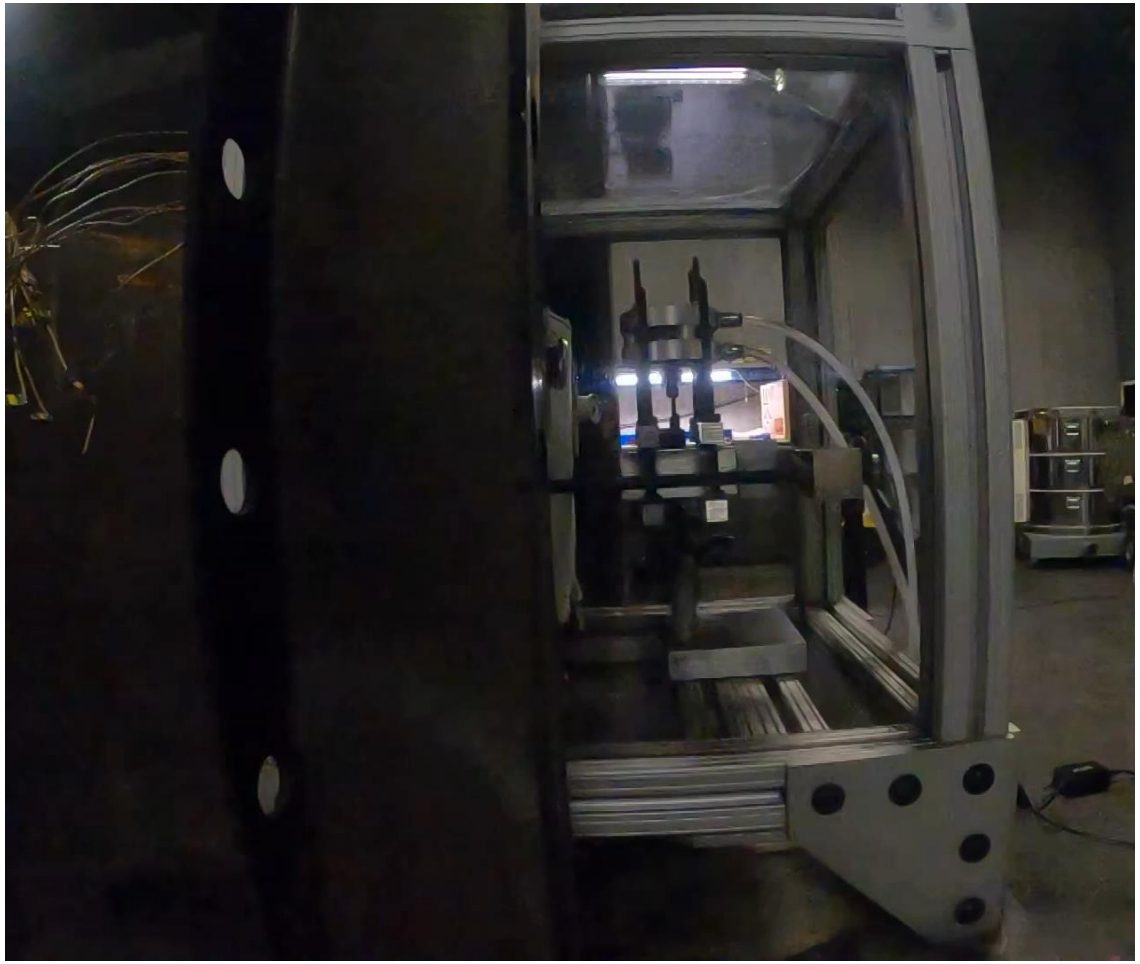
Material B



Evaluating Material Response to Thermal Runaway Ejecta

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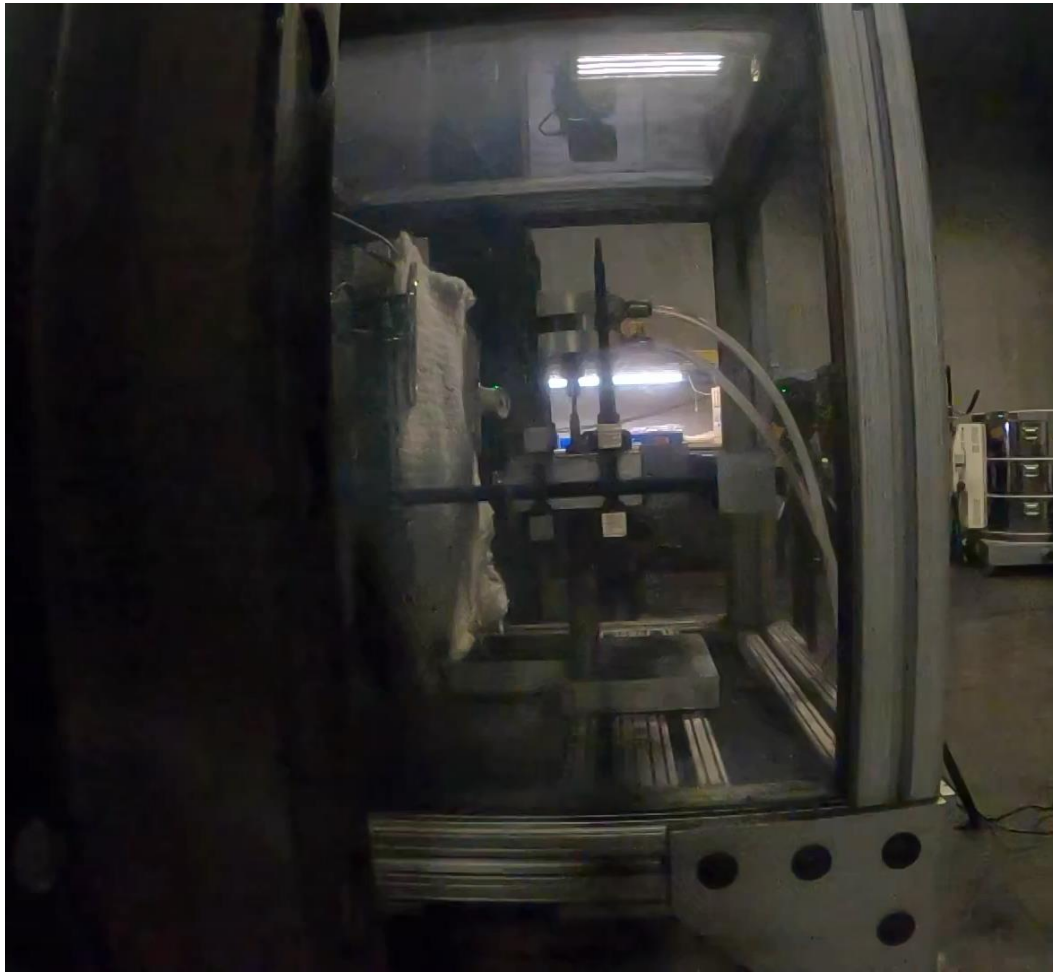
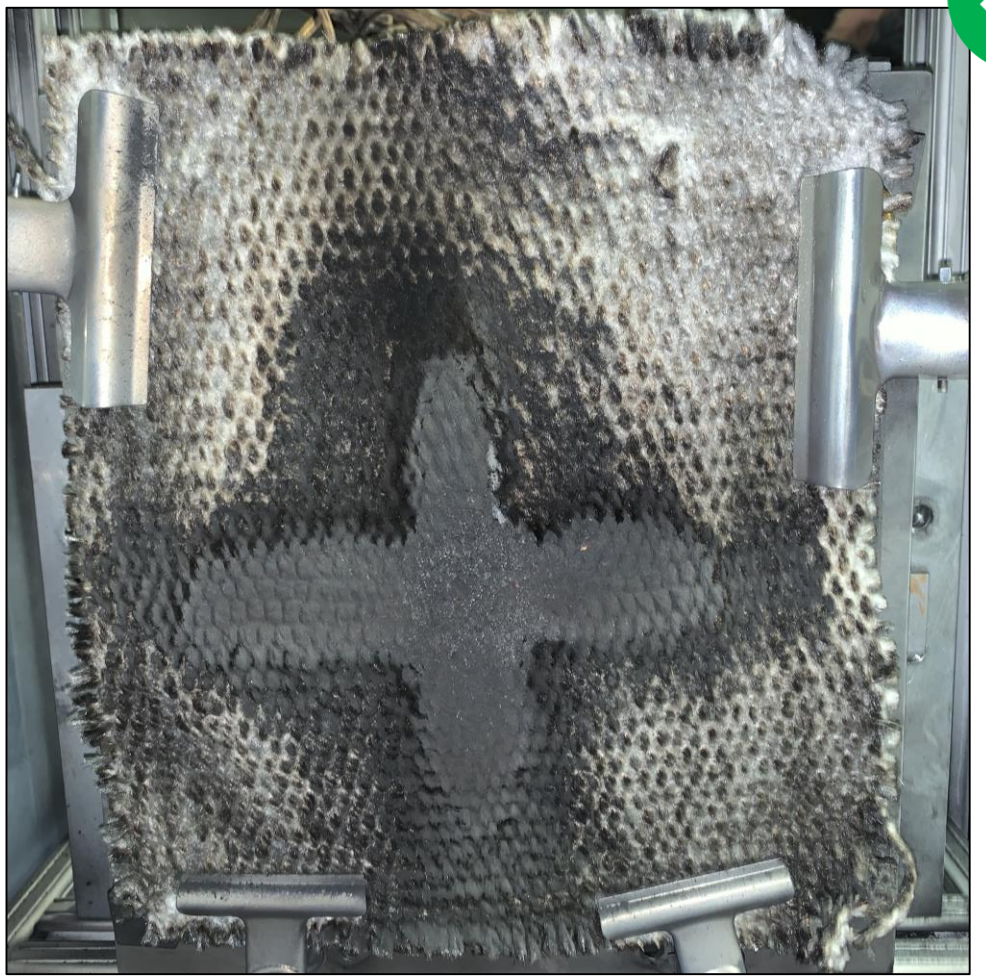
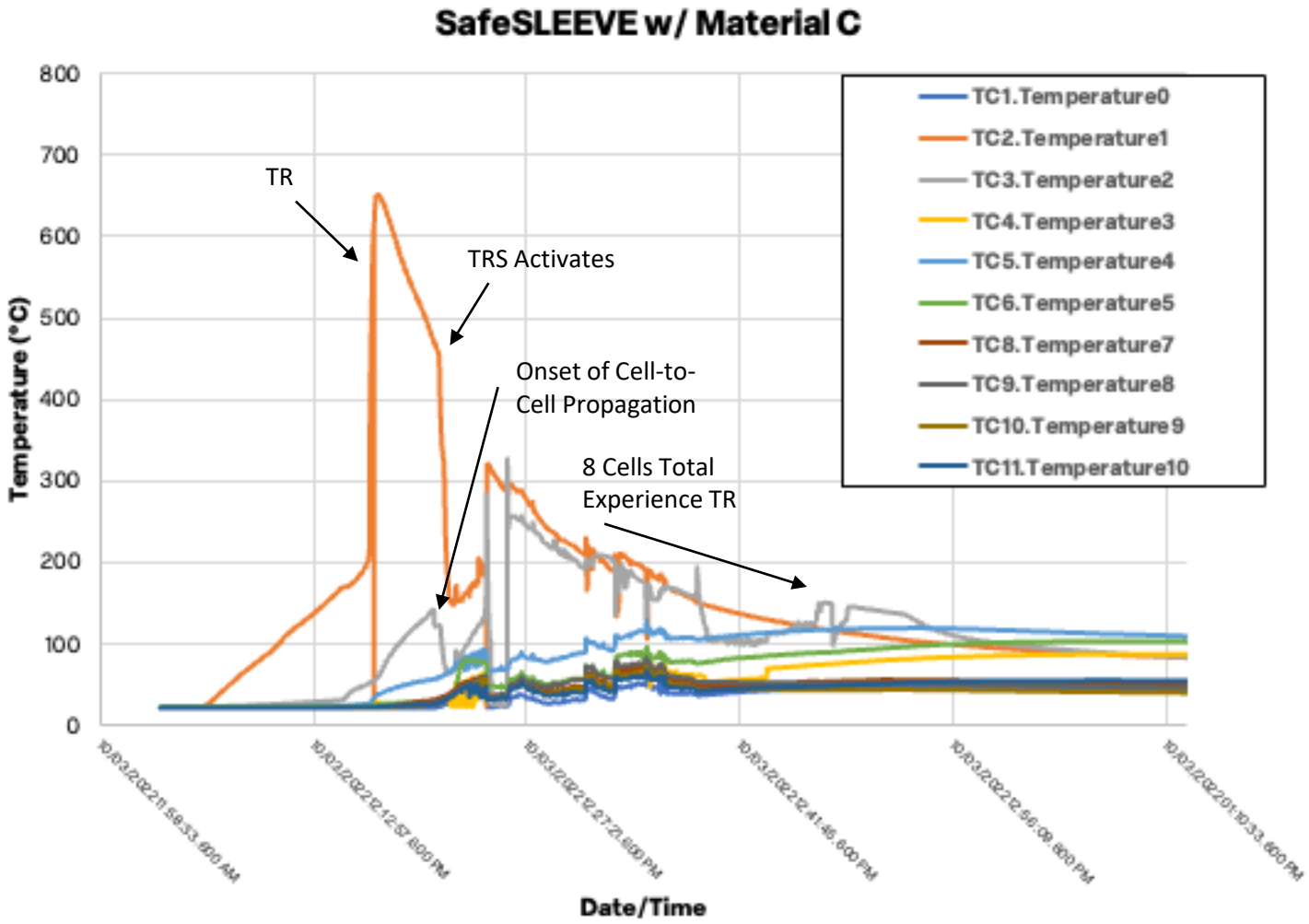
Material C





Evaluating Material Response to Thermal Runaway Ejecta

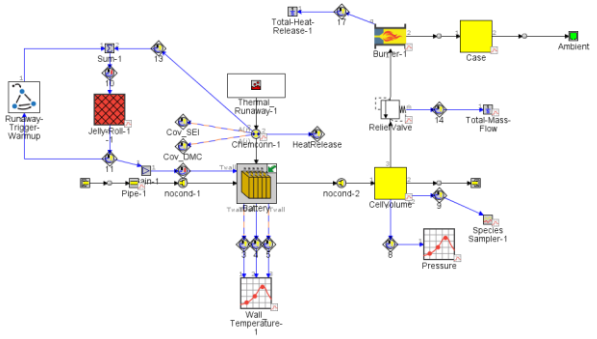
SafeSLEEVE w/ Material C

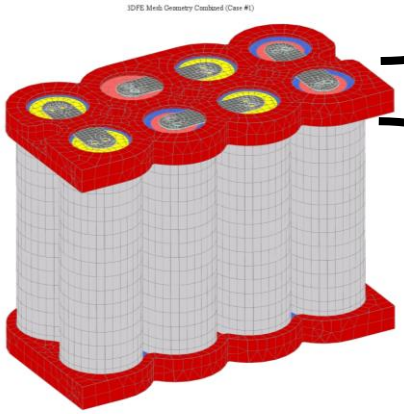


Analysis Driven Design

Using Multiphysics Analysis to Ensure Design Success

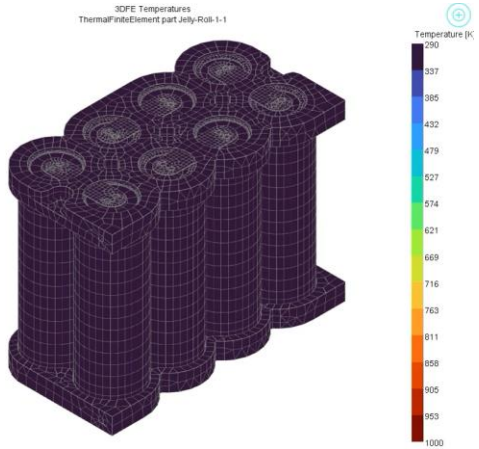
MULTI-PHYSICS LOGIC



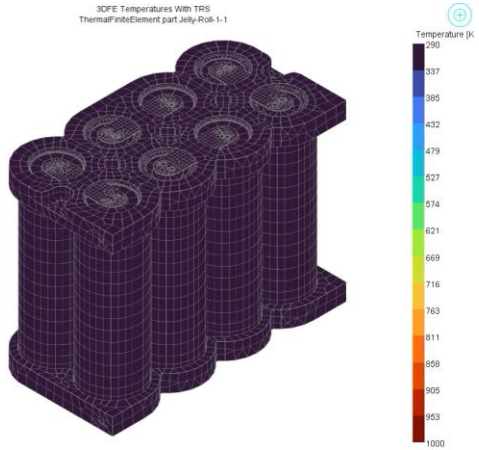


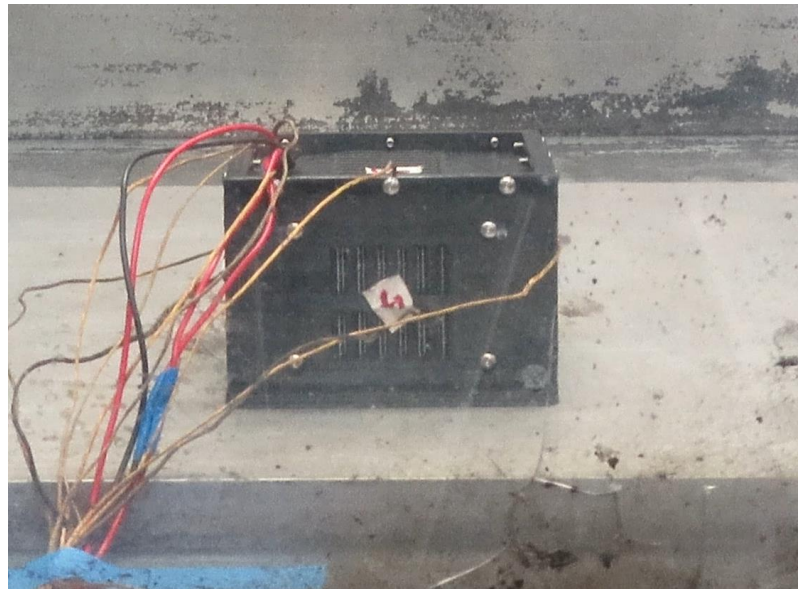
3-D FEM MODEL

WITHOUT TRS



WITH TRS

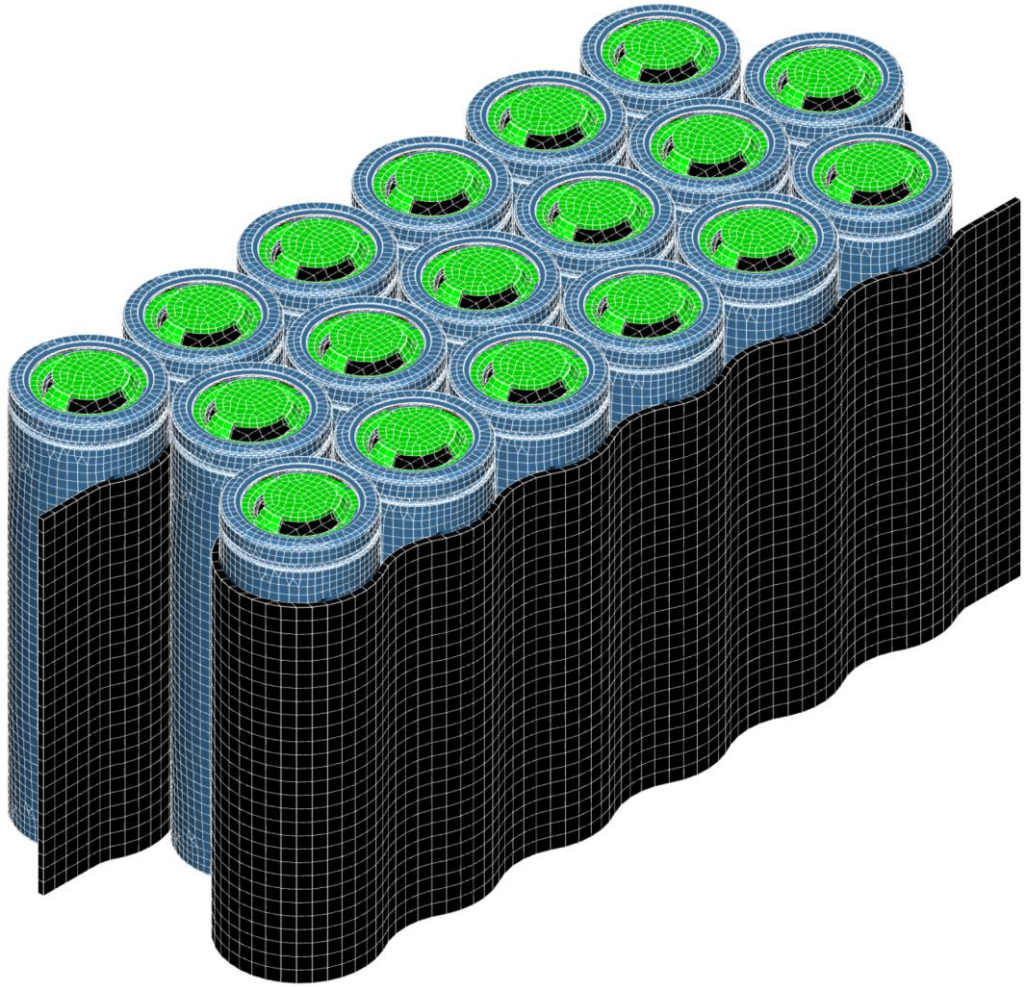


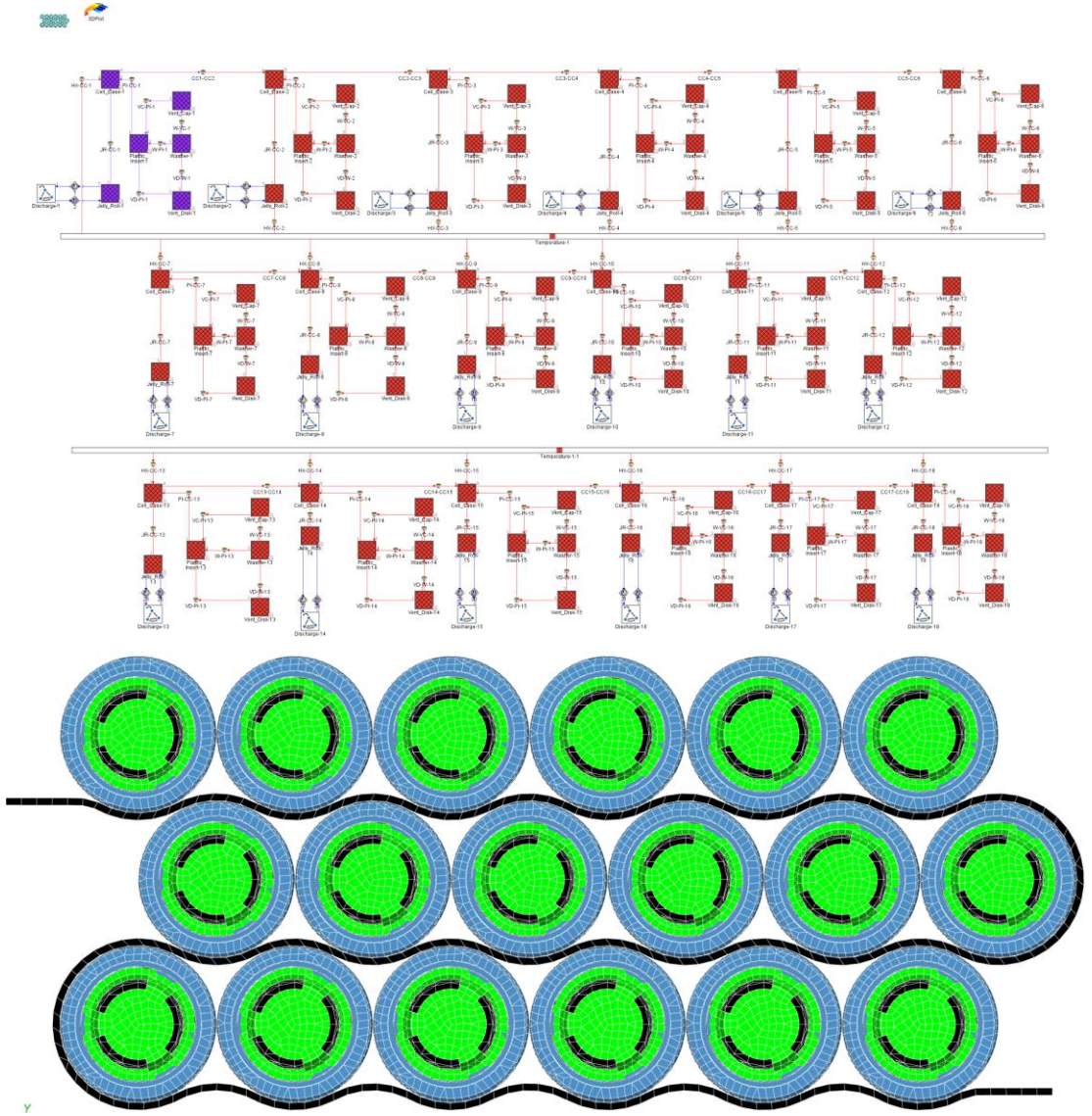


GAMMA TECHNOLOGIES

Parametric Studies for Design Optimization

Thermal Strategy, Spacing, and Heat Sinking





Future of Thermal Runaway Simulation

Combustion, Flame, & Material Degradation

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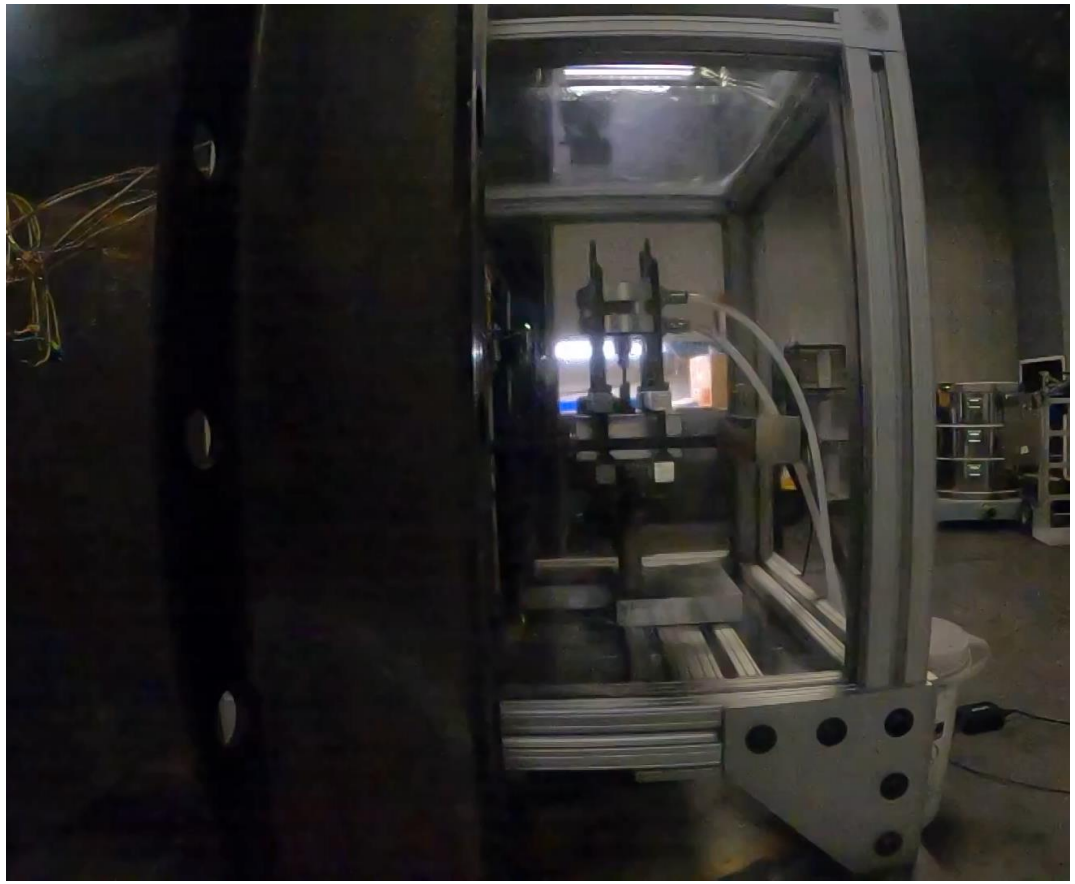

Exploring Co-Solving Capabilities for Combustion Simulation

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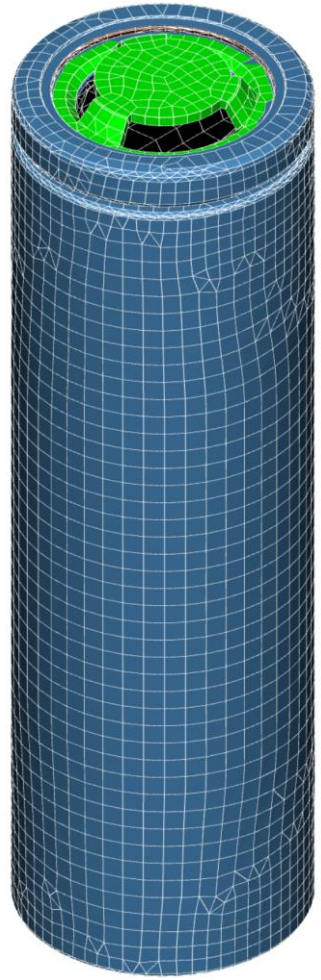
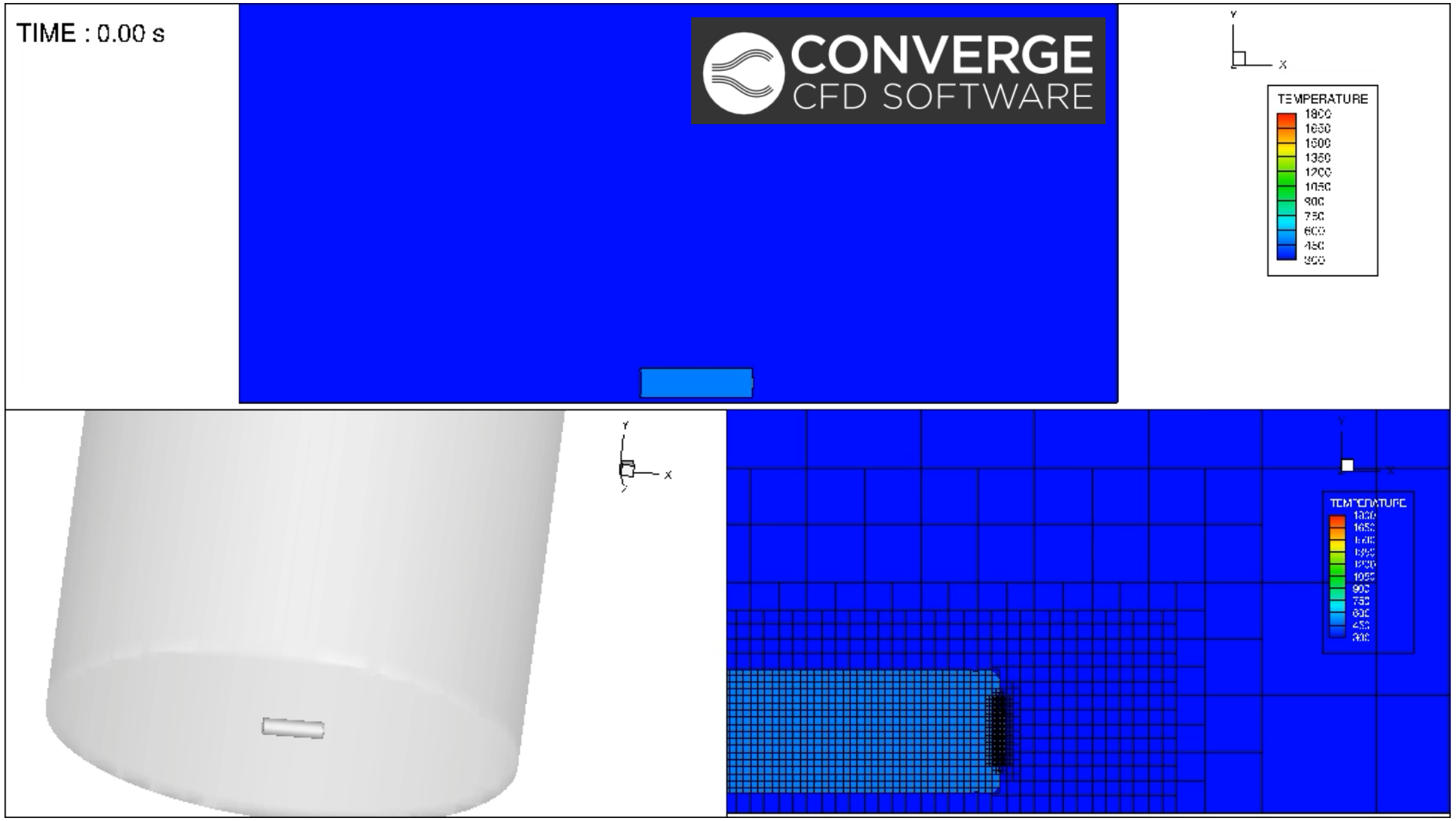


GAMMA TECHNOLOGIES



Summary

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KULR Technology Corporation is building an energy management platform to accelerate the global transition to circular electrification economy.

No silver bullet! A holistic approach is necessary when designing batteries and systems used to store and transport batteries.

Examples were provided for how testing can and should be used to address the complexities of material response to thermal runaway events.

Examples were also provided to describe the importance of driving designs with analysis.

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Secrets of the Universe

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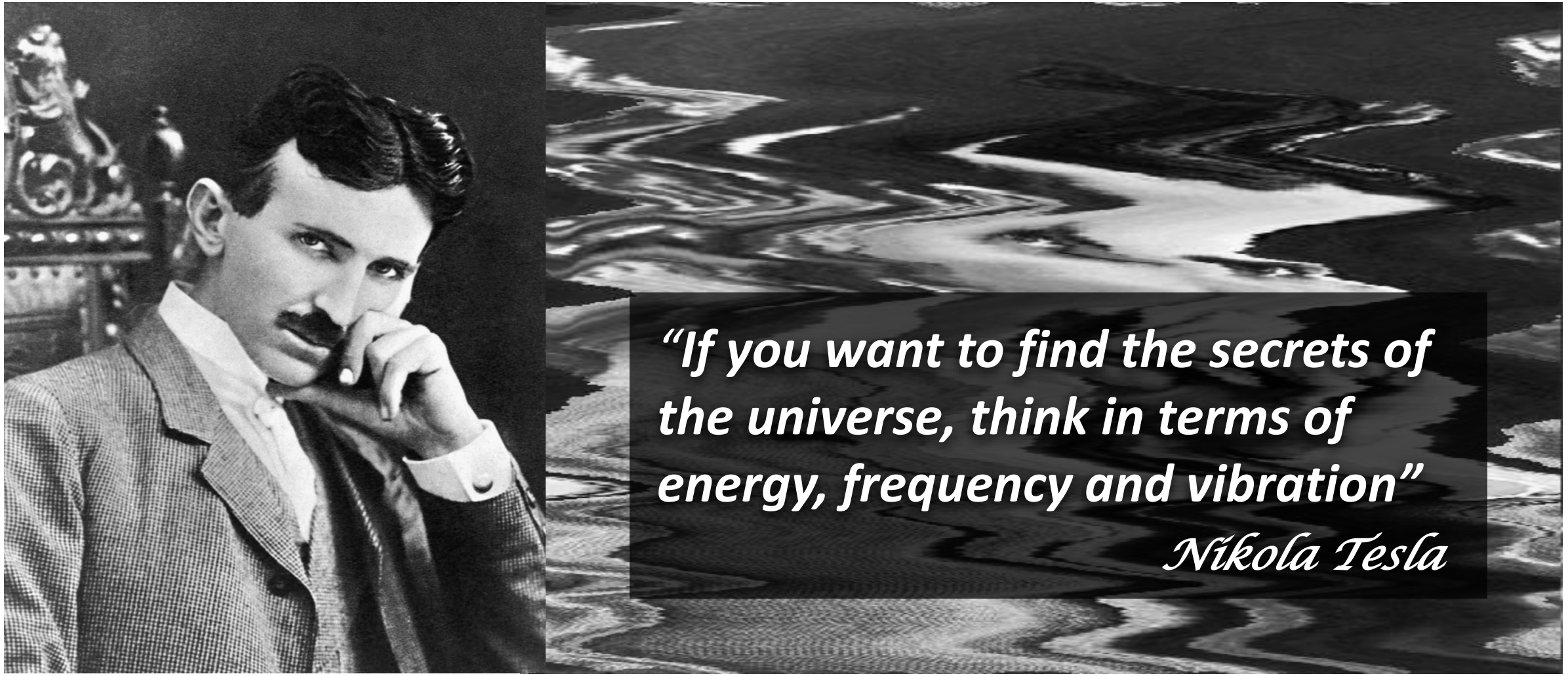

Vibration and Energy

Vibration is Energy

- Unwanted energy created, energy used, energy wasted
- Vibrations negatively affect freedom of movement, requiring more energy to spin or rotate an object or system of objects

Reducing vibration is *Sustainable Energy Management*

Frequency and amplitude are the measurements of severity

- Frequency is number of times of collision over time (ms to minutes)
- Amplitude is Inches Per Second (IPS) of movement

Examples of Destructive Vibration

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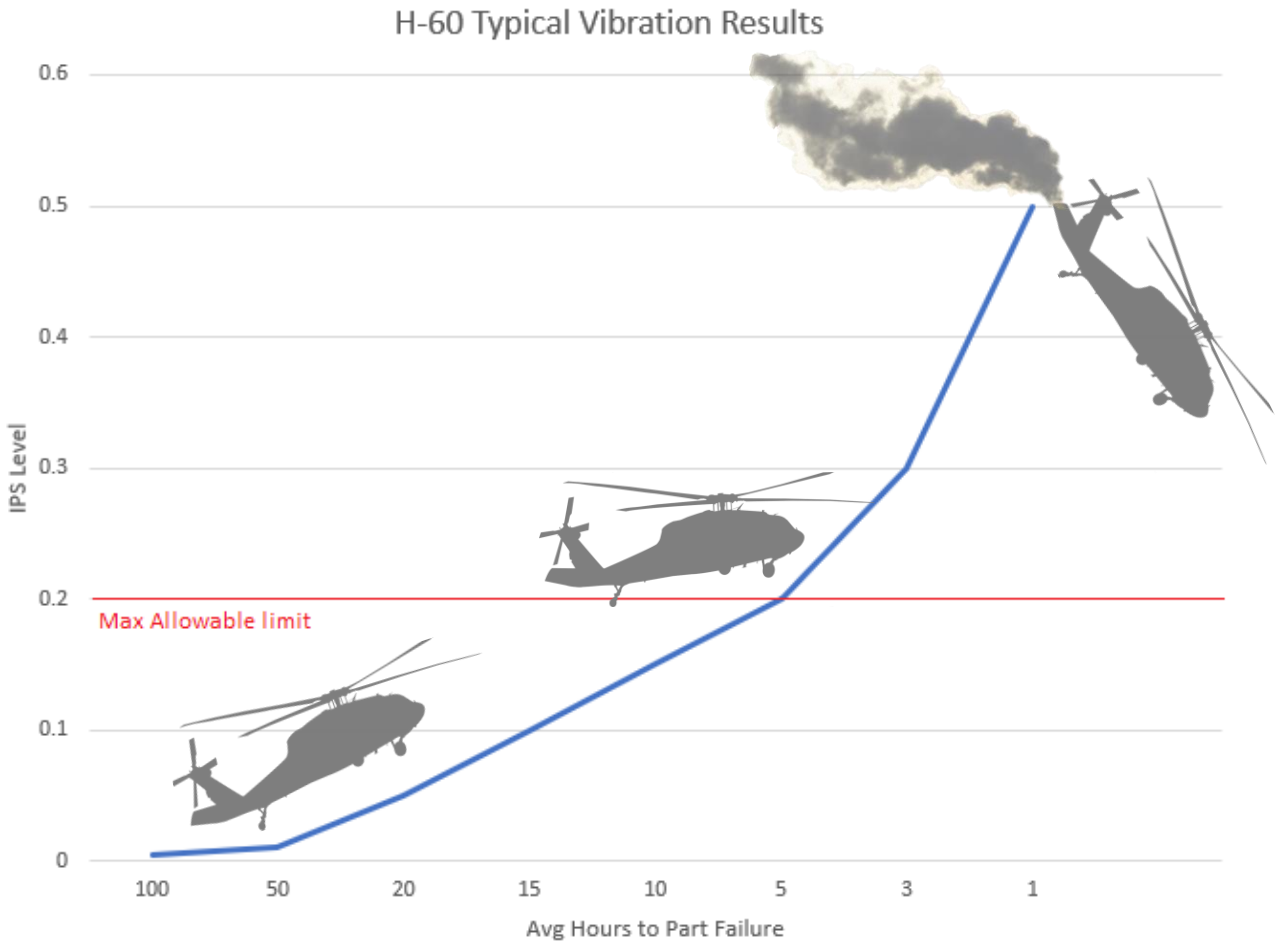
Aviation

Standard IPS Level	
0.00 – 0.09	Excellent
0.09 – 0.20	Good*
0.20 – 0.50	Bad
0.50 – 1.00	Severe
1.00 or higher	Catastrophic exponentially over time

* *Industry standard born in the 1960's due to lack of computer processing speed as well as the use of coefficients (law of averages) to solve complex balance problems*



Introducing KULR VIBE

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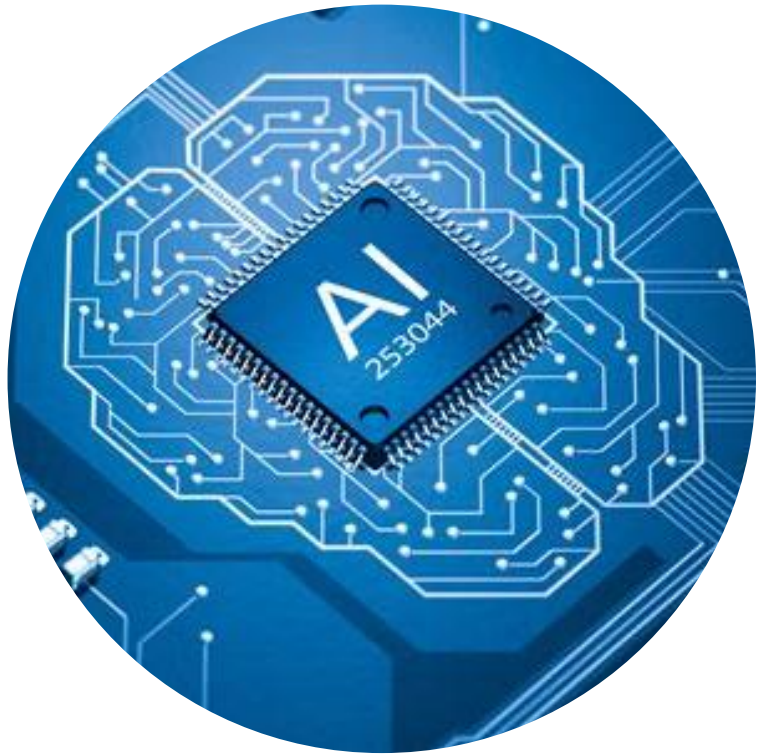
Artificial intelligence solution with “learning” algorithms that utilize data from sensors to reduce vibration for a more energy efficient system

For nearly twenty years, the primary applications have been aviation. However, advances in measurement and computing have allowed the KULR VIBE technologies to provide transformative, scalable solutions across transportation, renewable energy (wind), manufacturing, industrial, performance racing and autonomous aerial (drone) applications.



KULR VIBE Overview

Inputs and Outputs

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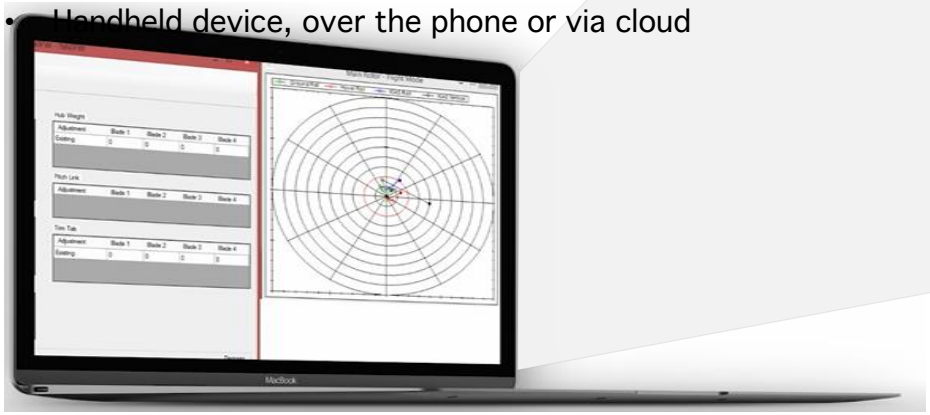
Data inputs from user

- Cloud, hard wired, plug-in, or manual readings of sensors from on-board or user carry-on equipment, or over the phone
- VIBE users only need IPS level and Phase Angle (clock position or degrees) to calculate a balance solution

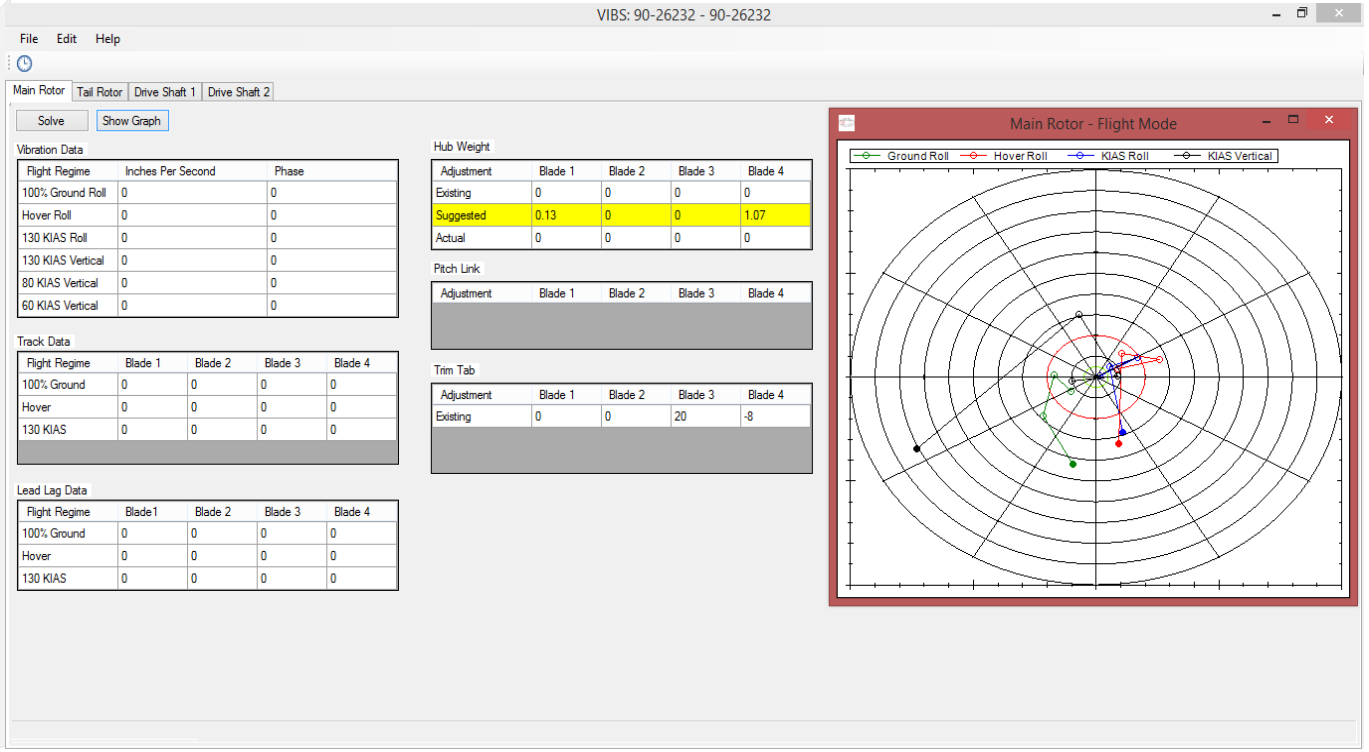
Graphical screen display

- User friendly,
- Adjustment suggestion (weight, pitch control rod, or trim tab),
- Handheld device, over the phone or via cloud



INTRODUCING

KULR VIBE™ | DECREASE YOUR VIBRATIONS INCREASE YOUR RELIABILITY



KULR VIBE Performance Successes

UH-1Z Viper Aircraft

KULR VIBE enables smooth operations and cost savings

39th Marine Air Group, Camp Pendleton, CA

- UH-1Z Viper Aircraft written off as “unfixable”.
- 78 flight hours
- KULR found improper orientation of vibration sensor hiding improper manufacturer part installation of the mast bearing.
- KULR VIBE saved $39M from boneyard.
- Aircraft has flown more than 150 hours since repair.

KULR VIBE

Next Steps

Continue using KULR VIBE to solve vibration problems.

Consider other areas of exploration:

- How does simulation and digital twin fit in with KULR VIBE?
- How can we continue to explore vibration with simulation by using GT-SUITE and available co-solvers (e.g. ART)?
- How can simulation, digital twin, and KULR VIBE be combined to reduce related loads on eVTOL batteries?