



Enhancing Lithium-Ion Battery Safety: Caltrans' Role in Mitigating Risks and Responding to Fires

Requested by

Michael Keever, Chief Deputy Director

Author

Mehdi Moeinaddini, Senior Transportation Planner, Office of Planning, Policy, and Program Development, Division of Research, Innovation, and System Information

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Executive Summary

Background

Lithium-ion (Li-ion) batteries are extensively used in electric vehicles (EVs) and energy storage due to their high energy density and efficiency. However, they pose safety risks, particularly in the event of thermal runaway, which can lead to fires and explosions. These risks are heightened by factors such as physical damage, overcharging, and extreme temperatures. Managing these hazards requires robust safety measures in battery design, quality control, regulatory frameworks, and emergency response preparedness.

As a major transportation agency, Caltrans must address these risks, particularly concerning highway safety, emergency response coordination, and hazardous materials transport. This summary identifies specific Caltrans needs and opportunities for action based on a review of research and existing policies.

Summary of Findings Relevant to Caltrans

Safety Risks and Challenges

- **EV Fire Risks:** EV battery fires present unique challenges, such as high-temperature combustion, toxic gas emissions, and the potential for fire reignition.
- **Hazardous Materials Transport:** Lithium-ion battery transportation incidents, such as truck fires, require improved regulations and emergency response protocols.
- **Infrastructure Safety:** Public charging stations and storage areas need fire suppression systems and emergency management protocols.

Key Research and Industry Practices

- **Key Research:** Current research on lithium battery safety focuses on safer designs, thermal runaway prevention, improved testing, fire-resistant packaging, and advanced battery management. Efforts include solid-state batteries, aerogel-infused packaging, and enhanced safety measures for electric vehicles and air transport.
- **National Initiatives:** Efforts like the U.S. Department of Transportation's Lithium Battery Safety Working Group and the National Highway Traffic Safety Administration's (NHTSA) Battery Safety Initiative focus on battery safety, manufacturing practices, and transportation regulations.
- **Fire Response and Training:** Agencies such as the National Fire Protection Association (NFPA) offer firefighter training programs for lithium-ion battery incidents.
- **State-Level Actions:** California agencies, including the Office of the State Fire Marshal and CAL FIRE, are developing guidelines for energy storage systems and public awareness campaigns.

Caltrans' Specific Needs and Strategic Actions

Regulatory and Policy Development

- Collaborate with federal agencies like NHTSA and Pipeline and Hazardous Materials Safety Administration (PHMSA) to enhance regulations on lithium battery transportation and safety.
- Establish state-specific guidelines for handling, transporting, and disposing of lithium-ion batteries in transit and waste management contexts.

Transportation and Infrastructure Safety

- Implement stricter inspection and monitoring of vehicles transporting lithium-ion batteries.

- Update hazmat transport policies to include lithium-ion battery-specific provisions for packaging, labeling, and segregation.
- Improve fire safety measures at EV charging stations and Caltrans-managed facilities.

Emergency Preparedness and Response

- Train Caltrans personnel and first responders in best practices for managing lithium-ion battery fires.
- Develop standardized incident protocols for roadway and transit system battery fires.
- Coordinate with local agencies to ensure a unified emergency response.

Public Awareness and Industry Engagement

- Launch educational campaigns on proper battery use, storage, and disposal.
- Engage with transport companies and battery manufacturers to align safety practices with state regulations.

Research and Innovation

- Support pilot programs and research into battery safety improvements, including new fire suppression technologies.
- Partner with academia and industry to advance next-generation battery safety solutions.

End-of-Life Battery Management

- Establish safe disposal sites and improve infrastructure for lithium-ion battery recycling.
- Develop protocols for handling damaged, defective, or recalled batteries to mitigate risks.

Implementation Mechanisms

To effectively execute these strategic actions, Caltrans can consider the following implementation mechanisms:

- **Policy and Regulation Development:** Work with state and federal legislators to draft policy amendments and advocate for standardized regulations.
- **Transportation Safety Monitoring:** Deploy automated safety monitoring systems and conduct periodic facility audits.
- **Emergency Response Coordination:** Establish inter-agency working groups and conduct joint emergency response simulations.
- **Public Awareness Initiatives:** Leverage social media, public forums, and industry conferences for outreach initiatives.
- **Research and Development Support:** Provide research grants and establish partnerships with universities and private-sector innovators.
- **Recycling and Waste Management:** Work with waste management firms to integrate battery recycling processes into existing hazardous waste programs.

Next Steps

A detailed review of implementation mechanisms, policy gaps, and coordination efforts is provided in the detailed findings section. These include enhancing regulatory frameworks, expanding research funding, and promoting inter-agency collaboration. By prioritizing these actions, Caltrans can proactively address lithium-ion battery risks and ensure public safety in California's evolving transportation landscape.

Detailed Findings

Background

Lithium-ion batteries (Li-ion) are widely used in applications like consumer electronics and electric vehicles because of their high energy density, long cycle life, and lightweight nature. Under normal conditions, Li-ion batteries are safe and reliable. However, their high energy density, while making them efficient, can also pose safety risks if certain factors are present. Although these risks are rare when the batteries are properly used and maintained, they can become significant if the batteries experience abnormal conditions, such as physical damage, overcharging, or extreme temperatures.

A primary cause of Li-ion battery fires is thermal runaway, a process in which an increase in temperature triggers reactions that further elevate the temperature, potentially leading to a fire or explosion. This can occur from overheating, overcharging, or physical damage. Additionally, internal short circuits—often due to manufacturing defects or damage—can generate excessive heat and cause fires. External factors, such as extreme temperatures, improper storage, and battery aging, which compromises safety mechanisms, can further heighten the risk.

When Li-ion batteries catch fire, they can release a significant amount of energy rapidly, creating intense fires that are difficult to extinguish. These fires can also release toxic gases, such as hydrogen fluoride, which pose additional health risks. In batteries with multiple cells, a fire in one cell can easily spread to neighboring cells, making the situation worse. To reduce these risks, it's important to incorporate safety features into battery design, such as pressure relief vents, thermal fuses, and effective separator materials. Additionally, strict quality control during manufacturing, educating users on proper battery handling and charging, and following regulatory standards are crucial for safety. Ongoing research and innovation are needed to develop safer battery technologies and improve existing safety measures to effectively address the risks of lithium-ion batteries. This review synthesizes the latest research, policies, and practices from various Federal and State agencies.

Lithium Battery Safety Working Group

The "[Report to Congress on Lithium Battery Safety Working Group](#)"¹ outlines the efforts of the U.S. Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration to address safety concerns related to lithium batteries. The report, mandated by the Federal Aviation Administration (FAA) Reauthorization Act of 2018, details the establishment of the Lithium Battery Safety Working Group, which includes various federal agencies like the FAA, Pipeline and Hazardous Materials Safety Administration (PHMSA), NHTSA, Consumer Product Safety Commission (CPSC), Food and Drug Administration (FDA), and National Institute of Standards and Technology (NIST).

Key findings and recommendations include:

- **Safety Risks:** The report identifies risks associated with lithium batteries, such as fires and explosions, due to overheating and thermal runaway.
- **Integrated Oversight:** The need for comprehensive inter-agency coordination to ensure the safe manufacture, transportation, and disposal of lithium batteries is emphasized.
- **Technological Innovations:** The report highlights the importance of researching new technologies to enhance battery safety.

¹ <https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2023-12/Report%20to%20Congress%20on%20Lithium%20Battery%20Safety%20Working%20Group.pdf>

- Regulations and Standards: The development and implementation of uniform transportation requirements and voluntary consensus standards are crucial for global trade and safety consistency.
- Collaborative Efforts: Federal agencies are encouraged to collaborate more effectively to manage risks and share data on lithium battery safety.
- Legislative Recommendations: The report suggests legislative measures to improve lithium battery safety and enhance regulatory frameworks.

Overall, the report emphasizes a systems approach to managing lithium battery safety, advocating for proactive risk management, enhanced safety regulations, and fostering innovation in battery technology.

NCHRP 20-132 project

The [NCHRP 20-132 project](#)² aims to develop an Electric Vehicle (EV) Fire Mitigation and Response Toolkit, addressing the unique challenges posed by lithium-ion battery fires in traffic incident management (TIM) and emergency management (EM) situations. The toolkit will provide state departments of transportation (DOTs) with best practices, guidelines, and strategies for managing EV fires, including fire suppression, infrastructure protection, and responder safety. It will also cover the risks associated with EV fires in various emergency scenarios, including natural disasters.

The research will include lessons learned, novel practices, and cost assessments related to lithium-ion battery fires. The toolkit will target primary audiences, such as DOT employees involved in TIM, fleet management, and EM, as well as secondary audiences like emergency responders and environmental services.

The project is budgeted at \$300,000 over 24 months, with deliverables including interim reports, a final toolkit, and educational materials. Proposals have been received, and the project panel is in the process of selecting a contractor.

NHTSA Battery Safety Initiative

The NHTSA is launching a [Battery Safety Initiative](#)³ for Electric Vehicles to address safety risks related to EV batteries. Key areas of focus include:

1. Data Collection: Analyzing data on EV battery safety, examining incidents, and conducting investigations of battery-related crash and non-crash events.
2. Research:
 - Battery Diagnostics: Evaluating battery health with early detection and intervention methods.
 - Cybersecurity: Investigating risks related to Battery Management System (BMS) communications and vehicle connectivity.
 - Charging Safety: Assessing safety for fast charging, wireless charging, and battery management systems.

² <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5689>

³ <https://www.nhtsa.gov/battery-safety-initiative#safety-standards>

3. Enforcement: Continuing investigations into potential defects linked to EV batteries and overseeing recalls for safety-related issues, such as vehicle and house fires.
4. Safety Standards:
 - Developing Phase 1 of the Global Technical Regulation (GTR) No. 20 for Electric Vehicle Safety.
 - NHTSA is also leading the development of Phase 2 of GTR No. 20, addressing issues like battery thermal runaway, water immersion, and vibration resistance.

These efforts aim to enhance the safety of electric vehicle batteries through research, testing, regulations, and enforcement.

National Fire Protection Association (NFPA)

The [TCRP E-14 project](#)⁴ focuses on developing a comprehensive guide for preventing and managing fire risks associated with lithium-ion battery transit buses as transit agencies move toward zero-emission fleets. With a \$350,000 budget and led by the Fire Protection Research Foundation, the research addresses key concerns such as thermal runaway, fire reignition, and the health risks posed by toxic gases. The project aims to identify root causes of battery fires, evaluate risk mitigation options, and establish best practices for fire suppression, battery monitoring, and safe fleet operations. Deliverables include a guide for transit agencies and manufacturers, a technical memorandum for implementing findings, and a final report documenting research activities and key recommendations to ensure the safe integration and scaling of zero-emission buses.

The National Fire Protection Association also offers [free training programs](#)⁵ for firefighters, police, and EMS personnel to address fires involving lithium-ion batteries in EVs. These types of training are crucial for effective emergency response in California, given the state's high adoption rate of electric vehicles.

Washington State Patrol (WSP)

The Washington State Patrol (WSP), through the State Fire Marshal's Office (SFMO), conducted a [study on electric vehicle \(EV\) fires](#)⁶ in [response to Substitute Senate Bill 5812 \(SSB 5812\)](#)⁷ from the [2024 Legislature](#)⁸. The study aimed to review impacts on the environment, residential areas, and firefighter health, as well as best practices for fire response and cleanup. Over 20 stakeholders from various sectors participated, including fire agencies, law enforcement, the towing industry, and environmental groups.

Key findings included that EV fires present unique challenges, such as higher temperatures, toxic gases, and the risk of explosions. These incidents require more water and time to extinguish, and damaged batteries may reignite later. Emergency responders are currently insufficiently prepared for these risks.

⁴ <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5258>

⁵ <https://afdc.energy.gov/case/3133>

⁶ https://app.leg.wa.gov/ReportsToTheLegislature/home/GetPDF?fileName=Electric+Vehicle+Fires+Study_SSB+5812_49de55f6-393a-4390-b668-daef0ad6b3b9.pdf

⁷ <https://wsafm.com/news/13441911>

⁸ <https://lawfilesexternal.wa.gov/biennium/2023-24/Pdf/Bills/Senate/Bills/5812.pdf>

The report provided 18 recommendations focusing on firefighter training, health protection, towing industry readiness, and environmental cleanup. Notable recommendations include:

- Developing specialized training for firefighters on EV fires.
- Providing protective equipment and health support for responders.
- Updating towing industry practices for handling EVs.
- Strengthening environmental protection and waste management practices after EV fires.

The report also included budgetary requests for creating a dedicated SFMO unit, grant programs for equipment, and resources for responders. Estimated costs for the implementation of these recommendations include \$1.35 million for firefighter training, \$6.6 million for equipment grants, and \$1.2 million for equipment needed by WSP.

Virginia Department of Transportation (VDOT)

[Emergency Management Strategies for Electric Vehicles](#)⁹: Electric vehicles (EVs), which account for 16.3% of new vehicle sales, predominantly use high-voltage lithium-ion batteries. These batteries pose unique risks when damaged, as they can enter thermal runaway. These risks necessitate specialized strategies and coordination among emergency services, including police, fire departments, tow companies, and the Virginia Department of Transportation (VDOT). This active project, funded with \$64,121 and led by the Virginia Transportation Research Council, aims to assess EV fire risks, review current suppression practices, engage with firefighters in Virginia and beyond, and identify VDOT's role in supporting EV fire management. The project started on November 1, 2024, and is expected to conclude by October 31, 2025. It focuses on highways, safety, human factors, and vehicle equipment, with the ultimate goal of enhancing EV emergency management and safety.

Florida Warning after Hurricane Helene

Florida Chief Financial Officer (CFO) & State Fire Marshal Jimmy Patronis issued [a fire safety warning after Hurricane Helene](#)¹⁰, highlighting the risks of lithium-ion batteries in flooded Electric Vehicles (EVs) and other devices. The storm's saltwater surge has caused at least 16 fires, including 6 from EVs. Compromised vehicles are fire hazards and should be moved to open spaces, unplugged, and safely disposed of. Patrons urged manufacturers to notify consumers and emphasized safety precautions such as venting, disabling vehicles, and following manufacturer guidelines.

New York Bills to Address the Lithium-Ion Battery Fires

Governor Kathy Hochul of New York signed a set of [bills aimed at addressing the dangers of lithium-ion battery fires](#)¹¹, which have been linked to nearly 270 fires that killed 18 people in NYC last year. These fires have surged due to the increasing use of e-bikes, especially during the pandemic, with many riders using faulty or “Frankenstein” batteries. The new laws prohibit the sale of substandard batteries, mandate that e-bikes, mopeds, and other devices carry warning tags, and require mopeds to be registered by dealers. The measures also enhance safety for emergency responders and aim to curb illegal activities associated with unregistered mopeds.

⁹ <https://trid.trb.org/View/2445135>

¹⁰ <https://myfloridacfo.com/news/newsletter/past-issues/news-details/2024/10/02/fire-safety-alert-cfo---state-fire-marshal-jimmy-patronis--lithium-ion-batteries-are-ticking-time-bombs-in-wake-of-hurricane-helene>

¹¹ <https://nypost.com/2024/07/11/us-news/hochul-signs-bills-to-extinguish-deadly-e-bike-battery-fires-that-killed-18-in-nyc/>

State Initiatives and Safety Measures

- Energy Storage Systems (ESS) Regulations: The California Office of the State Fire Marshal (OSFM) has developed guidelines for the safe implementation of [Energy Storage Systems](#)¹², which include lithium-ion batteries. These guidelines aim to mitigate fire risks associated with ESS installations.
- Lithium-Ion Battery Advisory Workgroup: [OSFM has established a workgroup](#)¹³ to address hazards and best practices related to fires involving Battery Energy Storage Systems (BESS) and mobility devices like e-scooters. The group may propose code changes, public education strategies, and fire service training to enhance safety.
- Lithium-Ion Car Battery Recycling Advisory Group: The [California Environmental Protection Agency \(CalEPA\) has published a report](#)¹⁴ focusing on the safe management and recycling of lithium-ion car batteries. The report emphasizes the hazardous nature of these batteries if not handled correctly and provides recommendations for their end-of-life management.
- Public Awareness Campaigns: CAL FIRE has been actively educating the public about EV fire safety. Through [social media platforms](#)¹⁵, they share resources from the National Fire Protection Association (NFPA) to inform and train individuals on lithium-ion battery safety.

Recent Incidents:

- [I-15 Lithium Battery Truck Fire](#)¹⁶: On July 26, 2024, a semi-truck transporting lithium batteries overturned and caught fire on Interstate 15 near Baker in San Bernardino County. The incident led to the shutdown of the highway, highlighting the potential hazards associated with transporting lithium-ion batteries. Caltrans and the California Highway Patrol responded promptly to secure the area and assist affected individuals.
- [Port of Los Angeles Battery Fire](#)¹⁷: In September 2024, a truck carrying lithium-ion batteries overturned near the Port of Los Angeles, resulting in an explosion and prolonged fire. The incident disrupted traffic and port operations, underscoring the complexities of managing large-scale battery fires.
- [Fire Erupts at Moss Landing Battery Plant](#)¹⁸: A fire broke out on January 16, 2025, at the Moss Landing Power Plant in California, a major lithium battery storage site, prompting evacuations and road closures. Firefighters let it burn out due to difficulties extinguishing lithium fires. The facility, owned by Vistra Energy, has had previous fires. While contained, concerns over air quality were raised. The cause remains unknown, and an investigation will follow once the fire is out.

¹² <https://osfm.fire.ca.gov/what-we-do/code-development-and-analysis/energy-storage-systems?>

¹³ <https://cdnverify.osfm.fire.ca.gov/media/su0i1532/lithium-ion-battery-workgroup-charter-draft-20230802.pdf>

¹⁴ https://calepa.ca.gov/wp-content/uploads/sites/6/2022/05/2022_AB-2832_Lithium-Ion-Car-Battery-Recycling-Advisory-Goup-Final-Report.pdf

¹⁵ <https://www.facebook.com/CALFIREOSFM/posts/concerned-about-ev-fire-safety-as-lithium-ion-batteries-power-most-electric-vehi/542694464823391>

¹⁶ <https://dot.ca.gov/news-releases/news-release-2024-027>

¹⁷ <https://www.theverge.com/2024/10/3/24261539/lithium-ion-battery-fire-la-truck-container-video-pepes-towing>

¹⁸ <https://www.ttnews.com/articles/fire-lithium-battery-plant>

Summary of Findings

Related Research and Resources

This summary covers various efforts and initiatives addressing the safety concerns associated with lithium-ion batteries, particularly in electric vehicles (EVs).

1. **Lithium Battery Safety Working Group:** A report by the U.S. Department of Transportation highlights the safety risks of lithium batteries, including fires and explosions, and recommends comprehensive inter-agency coordination, technological advancements, and uniform regulations for safety.
2. **National Cooperative Highway Research Program (NCHRP) 20-132 Project:** A project aimed at developing an EV Fire Mitigation Toolkit, targeting safety strategies and best practices for handling EV fires in emergency scenarios.
3. **National Highway Traffic Safety Administration (NHTSA) Battery Safety Initiative:** This initiative focuses on data collection, research, and enforcement around EV battery safety, including diagnostics, cybersecurity, and charging safety, along with developing safety standards.
4. **National Fire Protection Association (NFPA):** The TCRP E-14 project aims to develop a guide for preventing and managing fire risks in lithium-ion battery transit buses as agencies transition to zero-emission fleets. Key concerns include thermal runaway, fire reignition, and toxic gas risks. NFPA also Provides free training programs for emergency responders to handle lithium-ion battery fires in EVs.
5. **Washington State Patrol (WSP):** A study on EV fires concluded that such fires present unique challenges and require specialized firefighter training, better equipment, and updated practices in towing and environmental protection.
6. **Virginia Department of Transportation (VDOT):** A Virginia Transportation Research Council project (Nov 2024–Oct 2025, \$64,121 funding) aims to assess EV fire risks, review suppression methods, collaborate with responders, and define VDOT's role in managing EV-related emergencies.
7. **Florida Warning After Hurricane Helene:** Florida issues safety warnings regarding EVs in flooded areas, emphasizing the risk of fire from compromised lithium-ion batteries.
8. **New York's Legislative Response:** New York passed laws to address the surge in lithium-ion battery fires, particularly related to e-bikes, including regulations on battery quality, warning labels, and registration requirements for mopeds.
9. **State Initiatives:**
 - **California Office of the State Fire Marshal (OSFM):** Guidelines for safely implementing Energy Storage Systems and addressing lithium-ion battery fire risks.

- Lithium-ion Battery Advisory Workgroup: A workgroup focused on fire safety for Battery Energy Storage Systems and mobility devices.
- California Environmental Protection Agency (CalEPA) Report: Recommendations for safe management and recycling of lithium-ion car batteries.
- California Department of Forestry and Fire Protection (CAL FIRE) Campaigns: Public education efforts on EV fire safety.

Overall, these initiatives emphasize proactive risk management, regulation, and training to improve lithium-ion battery safety, with a focus on emergency preparedness, research, and legislation. In conclusion, the various initiatives and reports highlight the need for ongoing research to tackle the evolving challenges of lithium-ion battery safety, particularly in EVs. There is an emphasis on developing new technologies for early detection of battery issues, improving fire suppression methods, and enhancing safety standards for transportation and storage. In addition, research into next-generation battery technologies offers promising solutions to reduce safety risks and improve energy density. Collaborative efforts between federal agencies, state authorities, and private sectors are essential to advance these safety practices, refine regulations, and promote safer, more efficient battery technologies.

Gaps in Findings

Battery Design and Safety Features:

- Insufficient Research on Safe Battery Designs: There is a need for more research into developing safer battery designs that prevent thermal runaway and other failure modes. Current safety features like shutdown separators, vents, and non-flammable electrolytes require further exploration to improve their effectiveness.
- Mitigation Measures for Thermal Runaway: Research is lacking on effective mitigation measures to prevent the propagation of thermal runaway within battery cells or between cells in a package. This includes appropriate cell spacing and the use of materials that can prevent or contain thermal events.

Data and Information Sharing:

- Limited Inter-Agency Coordination: There is a need for improved data sharing and coordination among federal agencies, state authorities, and private sectors to better address the risks of lithium batteries and ensure a unified understanding of transportation requirements.
- Incomplete Data Collection: Some incidents involving lithium batteries are not consistently reported or documented, leading to gaps in incident data that are crucial for risk assessment and policy development.
- Limited Data on Incident Causes: There is a gap in detailed data on the root causes of battery incidents, which hinders the ability to develop targeted safety improvements.

Standards and Quality Control:

- Lack of Uniform Standards: While voluntary consensus standards exist, they are not uniformly applied across all industries and sectors, resulting in potential safety risks due to non-standardized practices.

- **Challenges in Standards Development:** Developing and maintaining standards that keep pace with technological advancements is a continuous challenge, and there is a need for harmonization of global standards to reduce complexity and ensure safety.
- **Inadequate Testing Standards:** Existing testing standards may not cover all potential failure scenarios, particularly under extreme conditions. There is a need for abuse testing that forces batteries into failure to better understand and mitigate risks.
- **Gaps in Standards for Emerging Technologies:** As new battery technologies like solid-state batteries are developed, research is needed to establish appropriate testing and safety standards for these innovations.
- **Inconsistent Quality Control:** Variability in manufacturing practices and quality control procedures can introduce safety risks, particularly in the transportation and use of lithium batteries.
- **Need for Comprehensive Systems Approach:** There is a lack of a comprehensive systems approach to lithium battery safety, which would integrate safety considerations throughout the entire lifecycle, from design to end-of-life.

Incident Response and Safety Measures:

- **Limited Proactive Safety Measures:** Existing safety measures are often reactive rather than proactive, focusing on addressing incidents after they occur rather than preventing them.
- **Need for Enhanced Safety Audits:** There is a need for enhanced safety audit programs to assess the operational management and quality control procedures of lithium batteries during their design and manufacture.

Regulatory Gaps:

- **Inconsistent Risk Management:** Different federal agencies have varying authorities, leading to inconsistent risk management across the battery lifecycle.
- **Evolving Technology:** The rapid development of lithium battery technology outpaces the existing regulatory framework, making it challenging to maintain current and relevant regulations.

Next Steps

Enhance Regulatory Frameworks

- **Update and Harmonize Standards:** Review and update existing standards to align with technological advancements and harmonize domestic and international regulations for lithium battery safety.
- **Develop Performance-Based Regulations:** Implement regulations that emphasize safety outcomes and allow for flexibility in innovation while ensuring adherence to safety benchmarks.
- **Expand Scope of Regulations:** Address gaps in oversight for emerging battery technologies, applications, and end-of-life management.

Promote Inter-Agency Collaboration

- **Establish a Permanent Inter-Agency Task Force:** Form a dedicated body to ensure continuous collaboration, data sharing, and coordinated responses among federal and state agencies.
- **Standardize Data Sharing:** Develop a centralized database for lithium battery incident reports, safety trends, and research outcomes to enable comprehensive analysis and informed decision-making.

- **Coordinate Safety Messaging:** Align safety outreach efforts across agencies to provide consistent and accurate guidance to manufacturers, transporters, and consumers.

Advance Research and Innovation

- **Fund Research on Safer Technologies:** Support studies into advanced battery chemistries (e.g., solid-state batteries), improved safety features, and fire mitigation technologies.
- **Develop Better Testing Protocols:** Create enhanced testing methods to evaluate battery performance under extreme and abuse conditions, ensuring reliability across all scenarios.
- **Encourage Public-Private Partnerships:** Collaborate with industry and academia to foster innovation and develop next-generation safety solutions for lithium batteries.

Strengthen Manufacturing and Quality Assurance

- **Implement Safety Audit Programs:** Require manufacturers to adopt internationally recognized safety audits and quality control processes throughout the battery lifecycle.
- **Promote Accountability:** Enforce stricter penalties for non-compliance with safety standards and encourage voluntary compliance through incentives.
- **Establish Certification Programs:** Develop accreditation or certification systems for manufacturers and supply chain participants to ensure consistent quality and safety.

Focus on Education and Outreach

- **Consumer Awareness Campaigns:** Launch initiatives to educate consumers on proper battery use, charging, and disposal to minimize safety risks.
- **Industry Training Programs:** Provide training for manufacturers, transporters, and retailers on best practices for lithium battery safety and compliance.
- **Stakeholder Engagement:** Create forums for regular communication between agencies, manufacturers, and other stakeholders to address emerging issues collaboratively.

Address End-of-Life and Recycling Challenges

- **Develop Safe Recycling Practices:** Establish protocols and infrastructure for the safe collection, transportation, and recycling of used lithium batteries.
- **Encourage Circular Economy:** Promote design-for-recycling approaches and incentivize the use of recycled materials in battery production.
- **Mitigate Risks of Damaged Batteries:** Implement specialized guidelines for the handling and transport of damaged, defective, or recalled batteries.

Caltrans Potential Contributions

As a State Department of Transportation (DOT), Caltrans can play a critical role in addressing the lithium-ion battery fires through several proactive and coordinated efforts:

1. **Policy and Regulation Development**
 - **Collaborate with Federal Agencies:** Work closely with federal agencies like PHMSA, FAA, and NHTSA to implement and enforce lithium battery-related safety regulations at the state level.
 - **Establish State-Level Standards:** Develop state-specific guidelines for the safe handling, transportation, and disposal of lithium-ion batteries, especially in transit and waste management contexts.

2. Transportation Safety Management
 - Integrate Battery Safety in Hazmat Transport: Update hazmat transport policies to include specific provisions for lithium-ion batteries, such as packaging, labeling, and segregation requirements.
 - Inspect and Monitor Transport Vehicles: Conduct inspections of vehicles transporting lithium batteries to ensure compliance with safety standards and minimize risks during transit.
3. Emergency Preparedness and Response
 - Equip Emergency Responders: Train first responders, including Caltrans personnel, on effective techniques for managing lithium-ion battery fires, including handling toxic emissions and mitigating thermal runaway.
 - Develop Incident Protocols: Create state-specific protocols for responding to lithium-ion battery fires on roadways, in transit systems, or at state-maintained facilities.
 - Partner with Local Agencies: Coordinate with local fire departments, emergency management agencies, and other stakeholders to ensure cohesive response efforts.
4. Infrastructure and Facility Safety
 - Provide Charging Infrastructure Guidelines: Work with manufacturers and utility providers to ensure public charging stations for electric vehicles meet fire safety standards and include fire suppression systems.
 - Enhance Rest Stops and Storage Areas: Ensure state-managed facilities like rest stops or storage yards are equipped with fire prevention and suppression systems for vehicles or goods containing lithium-ion batteries.
5. Public Awareness and Education
 - Consumer Outreach: Educate the public on the proper handling, storage, and disposal of lithium-ion batteries through campaigns, workshops, and informational materials.
 - Industry Engagement: Collaborate with transport companies, manufacturers, and waste management firms to raise awareness about lithium battery risks and safety practices.
6. Research and Innovation
 - Support Safety Research: Fund or participate in current research initiatives aimed at understanding and mitigating lithium-ion battery fire risks, particularly in the transportation context.
 - Pilot Safety Programs: Test and evaluate new technologies, such as fire-resistant packaging or advanced fire suppression systems, on state roadways and facilities.
7. Recycling and End-of-Life Management
 - Establish Safe Disposal Sites: Work with local governments and private entities to create accessible drop-off points for used or damaged lithium-ion batteries.
 - Promote Recycling Programs: Encourage and support programs that focus on the safe recycling of lithium-ion batteries, reducing the risk of fire from improperly discarded units.

To effectively execute these strategic actions, Caltrans can consider the following implementation mechanisms:

Policy and Regulation Development

- Collaborate with state and federal legislators to draft policy amendments and advocate for standardized regulations.
- Establish advisory committees to review and propose updates to existing safety guidelines.
- Align with national and international safety standards to ensure consistency across jurisdictions.

Transportation Safety Monitoring

- Deploy automated safety monitoring systems on highways and transit routes to track and mitigate risks associated with lithium-ion battery transportation.
- Conduct periodic safety audits at transport hubs, charging stations, and storage facilities.
- Develop a reporting framework for tracking and responding to lithium battery-related incidents.

Emergency Response Coordination

- Form inter-agency working groups to enhance collaboration between Caltrans, emergency responders, and local governments.
- Conduct joint emergency response simulations and drills focused on lithium-ion battery fire incidents.
- Provide specialized training and certification programs for emergency personnel handling lithium-ion battery fires.

Public Awareness and Industry Engagement

- Utilize social media, public forums, and industry conferences to disseminate battery safety information.
- Develop an online knowledge repository with guidelines, case studies, and best practices for lithium-ion battery safety.
- Partner with industry stakeholders to encourage voluntary compliance with best safety practices.

Research and Development Support

- Establish funding mechanisms such as research grants for academia and private-sector innovators working on battery safety solutions.
- Support pilot projects that test new fire suppression technologies and safer battery chemistries.
- Engage with technology firms to explore advancements in battery diagnostics and early failure detection.

Recycling and Waste Management

- Work with waste management firms to integrate lithium-ion battery recycling into existing hazardous waste programs.
- Develop incentives for consumers and businesses to participate in proper battery disposal initiatives.
- Implement stricter tracking and handling protocols for damaged or end-of-life lithium-ion batteries to prevent safety hazards.