U.S. Department
of Transportation
**Pipeline and Hazardous
Materials Safety
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

July 15, 2021

The Honorable Maria Cantwell
Chair
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

The enclosed constitutes the response of the Pipeline and Hazardous Materials Safety Administration (PHMSA) as required by Section 333(d) "Lithium Battery Air Safety Advisory Committee" (the Committee) of the Federal Aviation Administration Reauthorization Act of 2018, Pub. L. No. 115-254, 116 Stat. 3009 (the Act). The statute requires the Committee to submit a report to the appropriate committees of Congress. The views contained in this report are those of the Committee and not those of PHMSA or the Federal Aviation Administration (FAA). The report is submitted to the U.S. Department of Transportation (the Department) for the purpose of providing information and industry recommendations. PHMSA and FAA's roles are to provide guidance and technical assistance, but not to develop the content.

Specifically, the Act requires the Committee to describe and evaluate the steps being taken in the private sector and by international regulatory authorities to implement and enforce requirements relating to the safe transportation by air of bulk shipments of lithium ion cells and batteries. This report also identifies areas that warrant greater attention.

Specifically, the report recommends:

- Establishment of a lithium battery and equipment incident reporting system to capture information beyond what is required by existing regulatory requirements.
- Creation of a process for forensic evaluation and root cause analysis of lithium batteries and equipment involved in an aviation related incident.
- Definition of supply chain data and information relevant to aviation to ensure or improve transportation safety, including the optimal means to store, access, and deliver this accurate and verifiable information.

- Engagement with battery manufacturers and the aviation sector to better define the risk profile of batteries shipped in cargo compartments and effectively implement adequate safety management system principles.

We will consider all the recommendations and findings in the report as we continue to find ways to ensure the safe transportation of lithium batteries, which is a top priority for the Department.

I hope this information is helpful. A similar letter has been sent to the Ranking Member of the Senate Committee on Commerce, Science, and Transportation, and the Chair and the Ranking Member of the House Committee on Transportation and Infrastructure.

Sincerely,

Tristan H. Brown
Acting Administrator

Enclosure

U.S. Department
of Transportation
**Pipeline and Hazardous
Materials Safety
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

July 15, 2021

The Honorable Roger Wicker
Ranking Member
Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Wicker:

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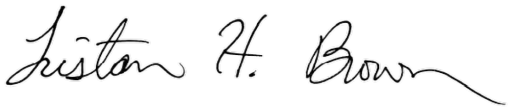

Tristan H. Brown
Acting Administrator

Enclosure

U.S. Department
of Transportation
**Pipeline and Hazardous
Materials Safety
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1200 New Jersey Avenue, SE
Washington, DC 20590

July 15, 2021

The Honorable Peter A. DeFazio
Chair
Committee on Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Chair DeFazio:

The enclosed constitutes the response of the Pipeline and Hazardous Materials Safety Administration (PHMSA) as required by Section 333(d) "Lithium Battery Air Safety Advisory Committee" (the Committee) of the Federal Aviation Administration Reauthorization Act of 2018, Pub. L. No. 115-254, 116 Stat. 3009 (the Act). The mandate requires the Committee to submit a report to the appropriate committees of Congress. The views contained in this report are those of the Committee and not those of PHMSA or the Federal Aviation Administration (FAA). The report is submitted to the U.S. Department of Transportation (the Department) for the purpose of providing information and industry recommendations. PHMSA and FAA's roles are to provide guidance and technical assistance but not to develop the content.

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Tristan H. Brown

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Acting Administrator

Enclosure

U.S. Department
of Transportation
**Pipeline and Hazardous
Materials Safety
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

July 15, 2021

The Honorable Sam Graves
Ranking Member
Committee on Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Ranking Member Graves:

The enclosed constitutes the response of the Pipeline and Hazardous Materials Safety Administration (PHMSA) as required by Section 333(d) "Lithium Battery Air Safety Advisory Committee" (the Committee) of the Federal Aviation Administration Reauthorization Act of 2018, Pub. L. No. 115-254, 116 Stat. 3009 (the Act). The mandate requires the Committee to submit a report to the appropriate committees of Congress. The views contained in this report are those of the Committee and not those of PHMSA or the Federal Aviation Administration (FAA). The report is submitted to the U.S. Department of Transportation (the Department) for the purpose of providing information and industry recommendations. PHMSA and FAA's roles are to provide guidance and technical assistance but not to develop the content.

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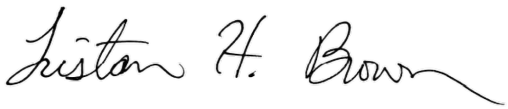


Tristan H. Brown
Acting Administrator

Enclosure

Lithium Battery Air Safety Advisory Committee Report

Pursuant to Section 333(d) of the "FAA Reauthorization Act of 2018"

Pub. L. No. 115-254, 116 Stat. 3009 (October 5, 2018)

January 2021

Table of Contents

Acronyms

ASIAS	Aviation Safety Information Analysis and Sharing
CAST	Commercial Aviation Safety Team
EV	Electric Vehicles
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
GWh	Gigawatt hours
ICAO	International Civil Aviation Organization
LCE Kt	Lithium Carbonate Equivalent Metric Kiloton
NRC	National Response Center
OEM	Original Equipment Manufacturer
OST	Office of the Secretary
PHMSA	Pipeline and Hazardous Materials Safety Administration
SAE	Society of Automotive Engineers
SME	Subject Matter Expert
SMS	Safety Management System
TRIP	Thermal Runaway Incident Program
UL	Underwriters Laboratories

Executive Summary

The increase in lithium-based battery products entering the marketplace is expected to result in more of these products being transported by air and carried on aircraft by passengers. Lithium-based batteries are a ubiquitous part of modern life and billions are safely used and transported every year. However, they represent a challenge to aviation safety that has been documented by the Federal Aviation Administration (FAA) and other aviation authorities. FAA data show incidents involving lithium batteries in cargo and checked and carry-on baggage from passengers increased year-to-year through 2019. In recognition of this challenge, the Federal Aviation Administration Reauthorization Act of 2018 required the establishment of a Lithium Battery Air Safety Advisory Committee (Committee). An assessment of the broad scope of the Committee yielded a substantial list of battery-related topics that include incidents, supply chain dynamics, regulatory implementation and hazard and risk assessment. To this end, four sub- committees were formed:

1. Data Collection and Analysis
2. Supply Chain Safety and Integrity
3. Regulations and Gap Analysis
4. Hazard Review and Risk Mitigation

The Data Collection and Analysis Sub-Committee is pursuing aviation battery incidents. The Supply Chain and Integrity Sub-Committee is addressing issues related to the design, testing, manufacturing, shipment of battery components, and intermediate assemblies of battery-containing products. The Regulations and Gap Analysis Sub-Committee is working on international battery regulations and the challenges facing implementation of normative regulations. Finally, the Hazard Review and Risk Mitigation Sub-Committee is reviewing issues related to battery failure, hazard characterization and analysis, risk assessment, improved mitigation methods and emergency response. Additional information on the Sub-Committees can be found in the "Background" section below.

This Committee is composed of experts throughout the lithium battery supply chain, emergency response, safety, and transportation industries. The purpose of the Committee is to advise the U.S. Department of Transportation on steps it can take to increase transportation safety of lithium batteries.

The Committee's experts recognize the challenge of the proprietary nature of lithium-based battery composition and design, and the multiplicity of lithium chemistries employed in complex cathode and anode architectures, each having different levels of safety. These factors have a profound influence on failure behavior (from benign to severe). It is this uncertainty that drives the need for the characterization of failure (temperature rise, venting, smoke emissions, electrical discharge, ignition, fire, and/or disassembly) for each battery system. This fundamentally represents the intrinsic hazard of the battery technology. Reliable tests to demonstrate failure modes have been developed to accurately measure these hazards under controlled conditions. As such, a new hazard-based dangerous goods classification system is under development by the United Nations Sub-Committee of Experts on the Transport of Dangerous Goods.

Considering these factors and challenges, the Committee held various meetings with subject matter experts, conducted surveys, and took research trips to develop findings. The following recommendations and next steps are for consideration by the Secretary of Transportation and Congress:

1. Establish lithium battery and equipment incident reporting system/database to capture information beyond that required by existing reporting mechanisms. Provide appropriate stakeholders with data and analysis from reporting mechanism.

2. Create a process for forensic evaluation and root cause analysis of lithium batteries and equipment involved in an aviation related incident.
3. Define all necessary supply chain data and information relevant to aviation to ensure or improve transportation safety, including the optimal means to store, access and deliver this accurate and verifiable information.
4. Engage with battery manufacturers and the aviation sector to better define the risk profile of batteries shipped in cargo compartments, and effectively implement adequate safety management system (SMS) principles.

The Committee is statutorily mandated to continue through 2025, and views these next steps as the basis for future recommendations.

This report describes the establishment of the Committee, an overview of the lithium battery marketplace, and details the Committee's recommendations and next steps. Upon the completion of this report, Committee members had the opportunity to review and provide independent statements. The report received consensus approval and no independent statements were submitted.

Overview and Formation of Committee Membership

FAA Reauthorization Act of 2018

The Lithium Battery Air Safety Advisory Committee (herein after referred to as the Committee) was mandated by Section 333(d) of the "FAA Reauthorization Act of 2018," Pub. L. No. 115-254, 116 Stat. 3009 (October 5, 2018). The Committee was established on May 9, 2019, under the Federal Advisory Committee Act (FACA) of 1972 (5 U.S.C., App. 2, as amended). The aim of the Committee is to facilitate communication concerning the safe transportation of lithium batteries by air amongst manufacturers of the batteries, manufacturers of lithium battery-powered products, air carriers, retailers and the Federal Government. (Unless otherwise stated herein, "lithium battery", “lithium batteries”, and “lithium-based batteries” refer to lithium ion and lithium metal cells and batteries.)

The Committee provides the Secretary, the FAA, and the Pipeline and Hazardous Materials Safety Administration (PHMSA) with timely information about new lithium battery technology and transportation safety practices and methodologies. Alternatively, it also serves to provide information to the Secretary and to discuss the activities of the DOT relating to lithium battery transportation safety, the policies underlying the activities, and positions to be advocated in international forums.

Additionally, the Committee serves as both a group of experts to provide information to the Secretary and receive advice on activities carried out throughout the world, to communicate and enforce relevant United States regulations and the International Civil Aviation Organization (ICAO) Technical Instructions, and to evaluate the effectiveness of these activities. The Committee will also assist the Secretary by communicating ways to best implement activities to increase awareness of relevant requirements and their importance to travelers and shippers. Further, the Committee will review methods to decrease the risk posed by air shipment of undeclared lithium batteries and efforts to educate those who prepare and offer hazardous materials for shipment by air.

The Committee is required to submit to the Secretary and the appropriate Congressional committees a report with recommendations identifying any areas for which there is consensus where greater attention is needed. The Committee is also required to describe and evaluate the steps being taken in the private sector and by international regulatory authorities to implement and enforce requirements relating to the safe transportation by air of bulk shipments of lithium ion cells and batteries. Throughout the Committee’s six-year tenure, it will continue to provide the Secretary with timely information about new lithium battery technology, and transportation safety practices and methodologies.

Formation of the Membership

When PHMSA solicited nominations for the Committee, the agency’s goal was to reach the widest audience possible to receive qualified nominations. As such, the agency developed a comprehensive outreach strategy and PHMSA received over 60 applications from candidates with diverse backgrounds and expertise. To select the 20 most highly qualified experts, PHMSA formed a Departmental review committee, which was composed of officials from PHMSA, FAA, and the Office of the Secretary of Transportation (OST). The review committee selected 20 expert members with diverse backgrounds in battery and product manufacturing, vehicle production, shipping, cargo and passenger air services, piloting, emergency response, fire safety research, and standards development. In accordance with the FAA Reauthorization Act, each member was appointed by the Secretary of Transportation to serve as a representative in a specific category (see Addendum 1 for more information).

The Committee held its first meeting on January 22-23, 2020, at the DOT Headquarters. The meeting was well attended and drew approximately 30 members of the public. During this two-day meeting, several members made presentations that covered:

- Lithium battery (domestic and international) transportation regulation changes
- Data on the type of batteries and devices, location of thermal runaway events observed in passenger carry-on, checked baggage, and cargo
- Overview of the voluntary Thermal Runaway Incident Program (TRIP) to collect and analyze data on lithium battery thermal events by certain airlines
- Examination of battery supply chain, including basic battery chemistry, compliance, and characterization of chemical, fire and electrical hazards and failure mechanisms

The Committee identified different aspects of the lithium battery life cycle and concluded that safety of the distribution system was dependent on the safe interoperability of all aspects of the life cycle. To address the critical safety characteristics, the Committee established four sub-committees. The creation of the following subcommittees was approved by the Department of Transportation, in accordance with 41 CFR § 102–3.35(b):

1. Data Collection and Analysis
2. Supply Chain Safety and Integrity
3. Regulations and Gap Analysis
4. Hazard Review and Risk Mitigation

Following the January meeting, the entire committee met on February 25-27, 2020, at the FAA Technical Center in Atlantic City, New Jersey to conduct a hazard review meeting. The purpose of this meeting was to educate Committee members on hazards associated with transporting lithium batteries by air. Discussions centered around emergency procedures for crewmembers, the importance of a layered approach for safety, and a review of mitigation strategies. In addition, live demonstrations of lithium battery abuse tests were performed, including demonstrations in an aircraft cabin environment. Finally, a tour of aircraft was conducted to highlight differences between aircraft class C and E compartments, and their capabilities to contain a lithium battery fire.

The Committee held its second and most recent formal meeting virtually on September 16-17, 2020. The two-day meeting drew over 86 attendees. The Committee considered the initiatives progressed by each Sub-Committee and prioritized the efforts necessary to advance safety. The Committee's consideration was further informed by presentations on the following current global initiatives that are intended to impact lithium battery transportation safety:

- Ongoing work by the Society of Automotive Engineers (SAE) G-27 on Lithium Battery Packaging Performance
- Ongoing work by the UN Sub-Committee of Experts on the Transport of Dangerous Goods Informal Working Group on Hazard Based Classification of Lithium Batteries and Cells
- Lithium battery proposals to be discussed at the 57th Session of the UN SCOE TDG and areas of focus for the upcoming ICAO DGP-Working Group/20
- NTSB Safety Recommendations A-20-31 & A-20-32 concerning the shipment of prototype or low production lithium batteries transported by air
- An update on PHMSA's Check the Box initiative to provide outreach concerning potential undeclared/mis-declared dangerous goods shipments

The next Committee meeting will be held March 3-4, 2021.

Lithium Battery Market Data

There is an increasing importance of lithium batteries in global commerce. Annual global sales of lithium-ion battery cells are expected to grow exponentially (Figure 1). It is estimated that their market value will increase from $28 billion in 2017 to about $77 billion in 2025. Global production will see an unprecedented growth across all market segments due to the rise in sales of electric vehicles (EVs), the main consumer of lithium-ion batteries (Publications Office of the European Union, 2018).

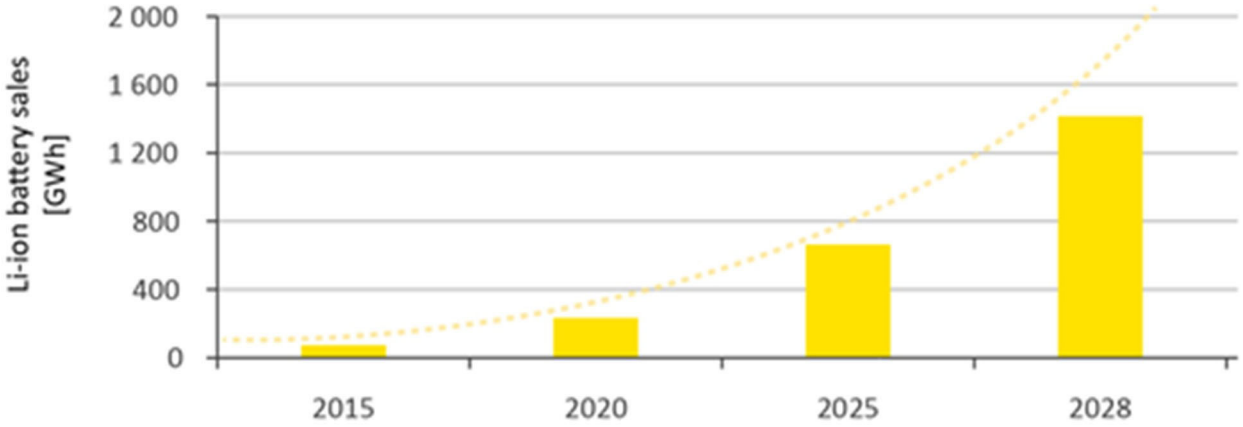


Figure 1: Expected lithium-ion battery sales in gigawatt hours (GWh)

At the same time, there is a worldwide commerce shift from traditional local retail to global e-commerce. Figure 2 shows the rise of e-commerce over the past few years and its estimated growth in the years to come (eMarketeer, 2019). This growth is expected to result in more lithium battery products being shipped by air. However, data on the quantity of lithium-based batteries being shipped by air freight is difficult to quantify.

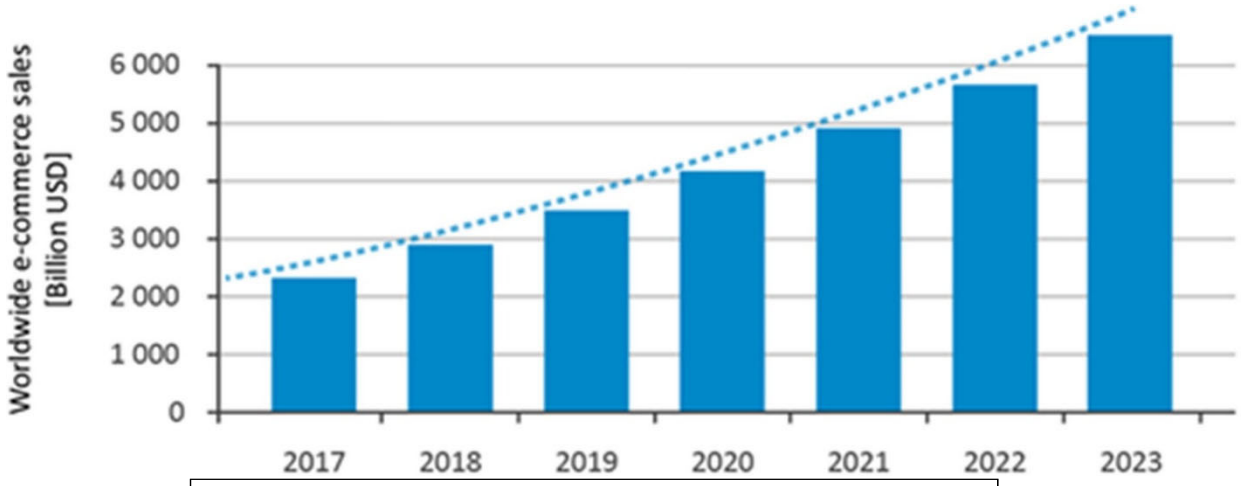


Figure 2: Expected worldwide e-commerce sales in billion USD

This global issue is driven by deeply integrated global supply chains. Lithium is mined on almost every continent; however, lithium battery cell manufacturing is heavily concentrated in Asia (China, Japan, and Korea), followed by production facilities in the United States and the European Union. In 2019, the

United States imported $3.6 billion of lithium ion batteries. That same year, the United States exported $1.4 billion of lithium ion batteries.[1]

In addition to the significant economic value of lithium battery shipments, PHMSA expects an increase in production of lithium ion cells. In the "Hazardous Materials: Enhanced Safety Provisions for Lithium Batteries Transported by Aircraft" rulemaking, PHMSA noted that in 2007 lithium ion cell production was at approximately 3 billion cells. By 2017 production had increased to over 7 billion lithium ion cells.

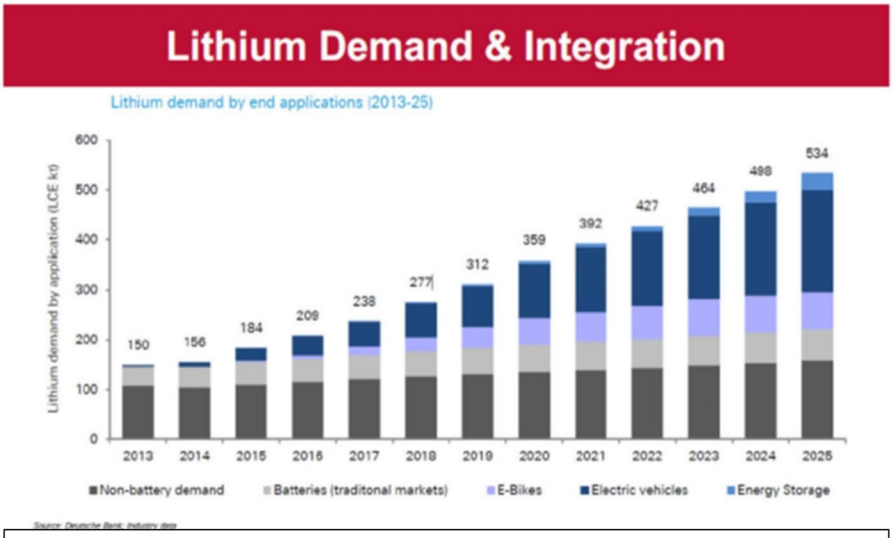


Figure 3: Lithium Demand and Integration. Note: Demand in Lithium Carbonate Equivalent metric kiloton (LCE Kt).

As seen in Figure 3, Deutsche Bank, as part of their 2016 Lithium 101 Report, also noted that certain lithium battery applications, specifically, e-bikes, EVs, and energy storage should continue to grow in the next 5 years.

[1] 2019 Online Census Data aggregated by PHMSA economists.

Committee Accomplishments

In addition to the meetings held in 2020, the Committee accomplished work outside of official and sub-committee meetings. However, in Spring 2020, the Committee paused operations due to the COVID-19 public health emergency. Many members' employers required them to quickly pivot their job functions to respond to the public health emergency and many served as integral members of their organization's COVID response. The Committee went on a 90 day pause and resumed activity in June 2020. Since resuming work, Committee leadership has met on a weekly basis and has held monthly Committee-wide meetings to advance work. The Committee faced another set back by the sudden passing of Member William B. Wojtas (United Airlines) in Summer 2020. Mr. Wojtas was the Regulatory Gap and Analysis Sub-Committee chair. Chairman Bob Brown graciously served as both Committee chairman and Sub-Committee chairman until Mr. Wojtas' role could be filled. Recently, member Mike Tobin (Alaska Airlines) was selected to lead the Sub-Committee.

After the Committee's January 2020 meeting, the members sent a letter, dated February 18, 2020, to Secretary Chao urging the Department's review and implementation of the U.S. Department of Homeland Security *Memorandum on Combating Trafficking in Counterfeit and Pirated Goods*. The Memorandum notes the national security and public safety concerns of imported counterfeit goods. Counterfeit lithium batteries are of concern to the Committee because of potentially poor design or manufacturing. Many counterfeit batteries are imported from China, and given the Trump Administration's efforts to negotiate a trade deal with China, the Committee believed it was timely to support efforts to stem the flow of counterfeit batteries from China. The letter encouraged the Department to review the Memorandum and engage the U.S. Trade Representative to seek a reduction in the importation of counterfeit lithium batteries. On April 27, 2020, PHMSA responded on the Secretary's behalf. The Agency thanked the Committee for their on-going work and commitment to lithium battery transportation safety. PHMSA discussed how the agency coordinates with the U.S. Customs and Border Protection's Commercial Targeting and Analysis Center to identify potential counterfeit and substandard lithium batteries to prevent safety issues in transportation.

Further, in February 2020, the Committees and invited subject matter experts (SMEs) held meetings at the FAA William J. Hughes Technical Center (FAA Tech Center). FAA generously provided the facility as a meeting venue and helped provide logistical support. The purpose of this meeting was to provide additional education for committee members on hazards associated with transporting lithium batteries by air. Discussions centered around emergency procedures for crewmembers, the importance of a layered approach for safety, and a review of mitigation strategies. In addition, live demonstrations of lithium battery abuse tests were performed, including demonstrations in an aircraft cabin environment. A tour of aircraft was conducted to highlight differences between class C and E aircraft compartments and their capabilities to contain a lithium battery fire.

Sub-Committees Background

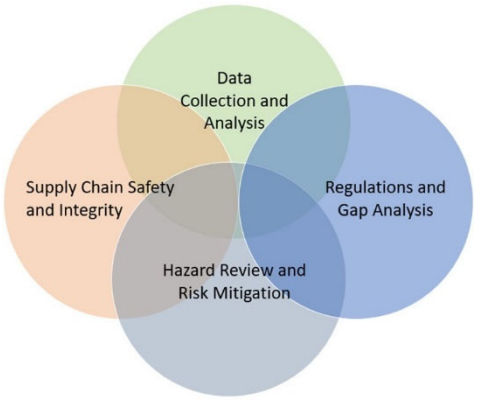


Figure 4: Sub-Committee Interoperability

The interoperability of the four sub-committees' work will lead to improved or enhanced safety. Although each sub-committee has different drivers, each sub-committee's findings help inform the other's work. The following provides brief background on the creation, purpose, and goals of each sub-committee.

Data Collection and Analysis Sub-Committee

The Data Collection and Analysis Sub-Committee was established because the Committee determined that identifying lithium battery and devices containing lithium batteries incident data in air transport is incomplete and fragmented. For example, in 2019, FAA data reflected 45 lithium battery events; however, that same year data compiled from U.S. airlines using TRIP reflected 96 events. Further, the Committee recognized that current data collection efforts have not yielded detailed analysis for targeted mitigation efforts. The goals of the Data Collection and Analysis Sub-Committee are multi-layered. Namely, the Sub-Committee seeks to develop accurate, complete, and timely accounting of lithium battery and device incidents related to air transportation to better understand the scale and complexities of safety related issues. By developing a complete picture of lithium battery failures, including documenting any available information associated with the incident and associated impact and emergency response activities, it will enable the Sub-Committee, and other appropriate entities (e.g., the Commercial Aviation Safety Team), to identify trends and recommend future mitigation opportunities. All together, these steps will develop knowledge, raise awareness, and increase transparency of safety issues.

Supply Chain Safety and Integrity Sub-Committee

The Supply Chain and Integrity Sub-Committee analyzes all aspects of the lithium battery supply chain, from product conception to the defined shipment (cargo) of batteries and battery-powered devices that enter airlines operations. This includes battery devices that are permanently installed on aircraft, devices used by flight crews, and passenger belongings (within checked luggage or carry-on). The goal of the Sub-Committee is to enhance safety requirements by attributing risk based on quantified hazard measurements and battery characteristics, while aiming to limit the burden to manufacturers that have demonstrated high quality design, manufacturing and quality control programs and associated data on the products in question. As such, the Sub-Committee will identify key parameters to define the scope of the battery supply chain for safe transport and shipment. These include opportunities for improvement in supply chain validation, authenticity of product information, and eventual recommendations for improvements in supply chain safety.

The Sub-Committee analyzed a model of the supply chain and agreed that technology can provide benefits to manufacturers and improve aviation safety. The group also recognizes the need to promote greater involvement of e-commerce platforms in the advancement of supply chain integrity. The Sub-Committee agreed to base further discussions on the supply chain process flow-chart presented by the chairman, Tom Chapin (Underwriters Laboratories), and expand discussion on opportunities to validate supply chain integrity utilizing an eight-step process developed by the group.

Regulations and Gap Analysis Sub-Committee

The Regulations and Gap Analysis Sub-Committee goal, under the leadership of Member William Wojtas (United Airlines), was to review and identify risks in relation to the regulations on the safe air transport of lithium ion batteries. The Sub-Committee undertook an SMS approach led by SMS experts from United Airlines. This review included identifying key risks within the aviation system, defining how these risks are addressed by regulation risk controls, and defining gaps in regulatory controls. This work defined the risk categories and a safety risk analysis of each identified hazard began. The Sub-Committee developed a process to assign a priority ranking to assess the regulatory gaps and proceed with mitigation proposals. The original objective of this group was to apply this method to all applicable regulatory provisions**.**

As discussed previously, the Sub-Committee's work faced a setback because of the unexpected passing of William Wojtas. In the interim, Chairman Brown took over as temporary Sub-Committee Chairman. As previously noted, member Mike Tobin (Alaska Airlines) has been selected to lead the Sub-Committee. This change in leadership provided an opportunity to reassess the objectives of the Sub-Committee, now considering changes in available SME resources and approaching ICAO Annex 6 Chapter 15 implementation of safety cargo risk assessments applicable to aircraft operators. The Sub-Committee will be examining the current challenges faced by airline operators in implementing regulatory requirements. The Sub-Committee expressed interest in focusing on ICAO Annex 6 Chapter 15 recommendations and Safety Risk Management requirements. Members also expressed interest in counterfeit products, undeclared shipments, regulatory complexities, education, and outreach. As such, Captain Brown provided a video presentation highlighting how an airline's SMS process works and the upcoming ICAO Annex 6 Chapter 15 recommendations taking effect in November 2020.

Hazard Review and Risk Mitigation Sub-Committee

The Hazard Review and Risk Mitigation Sub-Committee was established to educate the Committee members on the hazards posed by lithium batteries in transport, available aircraft loading mitigation measures, and various aircraft fire mitigation capabilities. All Committee members are also members of this Sub-Committee, which will continue to convene on an ad-hoc basis, at the direction of Committee leadership, to support the other three Sub-Committees. The Committee decided to focus the Hazard Review and Risk Mitigation Sub-Committee on examining a layered safety approach (battery, package, container, aircraft) and the variation of aircraft compartments (cargo, passenger, different locations/compartments). As discussed above, in February 2020, the Committees and SMEs held a three-day meeting at the FAA Tech Center.

Committee's Recommendations and Next Steps

The Committee provides the below recommendations, or areas which there is consensus that greater attention is needed, for the review and consideration by the Secretary of Transportation and appropriate members of Congress. As directed by the FAA Reauthorization Act of 2018, the work of this Committee will continue through 2025. As such, the Committee views this as the first set of recommendations, with additional recommendations to come. The Committee assessed both Section 333(d)(4)(A)(i) and (ii) in the formulation of these recommendations, and it is expected the Committee's future work will inform additional recommendations.

1. **Establish an enhanced lithium battery and equipment incident reporting system/database to capture information beyond what is required by regulation or provided through existing reporting mechanisms. Provide appropriate stakeholders with data and analysis from reporting mechanism (to working groups like the Commercial Aviation Safety Team (CAST) and others).**

   Current Reporting Requirements (See 49 CFR § § 171.15 & 171.16): If, during transport by aircraft, a fire, violent rupture, explosion or dangerous evolution of heat occurs as a direct result of a battery or battery-powered device, the following reporting requirements are in place:

   - The National Response Center (NRC) by telephone as soon as practicable, but no later than 12 hours after occurrence.
   - The FAA by email following the FAA Hazmat Notification procedure.
   - DOT/PHMSA by DOT Form 5800.1, within 30 days.

   Other non-U.S. required reporting:

   - Other aviation authorities depending on location (i.e. foreign country).
   - Some airlines make additional other voluntary reports (TRIP, IATA).

   Suggested Reporting Requirements: The Sub-Committee has worked closely with Underwriters Laboratories (UL) which provided an overview of TRIP. TRIP is a voluntary aviation battery incident tracking system conceived by United Airlines and American Airlines approximately four years ago, with development assistance from UL. TRIP is used voluntarily by several airlines for lithium battery incidents. While at the FAA Tech Center, the Sub-Committee reviewed TRIP's data paths with current domestic and international regulatory data collection requirements. Further, the review provided an overview on how TRIP was developed, including the scope of data captured and data sources. The Sub-Committee came to agreement on the scope of data collection and limited it to domestic carriers operating anywhere in the world and foreign carriers operating in the U.S. The Sub-Committee also determined that the data should be collected for all lithium battery incidents where the battery was intended for transport via aircraft. The Sub-Committee members have provided suggestions on additional data collection needed for battery incidents, which includes those additional data elements from TRIP and those elements not being collected by regulation or TRIP:

   - Flight details where applicable (flight number, position on aircraft, phase of flight, unit load device type) – Included in TRIP
   - Event preceding the incident – Included in TRIP
   - Device type – Included in TRIP
   - Device brand /manufacturer & model – Included in TRIP
   - Validity of UN 38.3 testing
   - Any modifications to battery / device
   - Use of any non-OEM parts (i.e. batteries) in the device

- Authorized repairs
- Forensic evaluation and root cause analysis of failure
- Compliance with regulatory requirements
- State of charge of the battery

Why is this necessary? The Sub-Committee members and SMEs reviewed current reporting requirements (U.S. and International) and other voluntary reporting methods for lithium battery air incidents. Current requirements were determined to be lacking on the collection of needed data, the performance of data analysis, and dissemination of resulting output. The group also discussed the availability of lithium battery incident data and observed a gap in manufacturer incident notification. Additionally, critical information pertaining to an incident that may help identify probable cause and/or systemic issues related to the current safety system program is not being captured (Addendum 3, figure 4 for further information on data gaps). Often, the manufacturer is not the shipper, and as shown in the data fields, the manufacturer is usually not identified. Ultimately, this results in the battery manufacturer/device manufacture not being aware that their product was involved in an incident.

Data for lithium battery (and device) incidents in air transport is incomplete, fragmented, often generalized, and can be misleading. Current data collection efforts have not yielded detailed analysis that allows for targeted mitigation efforts. Further, some regulatory requirements that are the responsibility of the shipper cannot be validated by the airlines (who are typically the incident reporter). Specifically, the battery's state of charge and the validity of UN 38.3 Test Summary present validation concerns.

Improving the types of information collected and shared with appropriate entities can enhance the overall understanding of the scope and severity of lithium battery incidents in air transportation. This information is vital to inform the work of the other sub-committees, regulators, and even manufacturers, to help influence further outreach, enforcement, and improved manufacturing SMS procedures.

SMS is a key factor. The more that is known, the better the SMS process becomes. For example, understanding how often there is a lithium battery device incident only provides general information. It is much more useful if we understand how often we have, for example, a power bank incident. Further, understanding how often a power bank issue occurs in a passenger cabin and being able to identify the manufacturer will be even more helpful (Addendum 3, figure 1).

Additional items to consider: One option would be to have the reporting system and data reside in FAA's Aviation Safety Information Analysis and Sharing (ASIAS) system. Furthermore, UL's TRIP reporting system (database and user interface) could be considered as a template for the type of system to be created or TRIP could be enhanced for use by all incident reporters.

2. **Create a process for forensic evaluation and root cause analysis of lithium batteries and equipment involved in an aviation related incident.**

Current process for forensic evaluation and root cause analysis: Currently, there are no formal processes for forensic evaluation. Collection and testing of batteries and devices involved in an incident aboard an aircraft, or in an airport or air cargo facility, may or may

not happen. Each carrier is left to determine its own process. When evaluation does take place, it is not clear who can secure custody of the battery, which entity should perform the evaluation/root cause analysis (e.g., local government, federal government, carrier, etc.) and to whom the results should be reported. There is no standard forensic process to follow. To take mitigating action, it is necessary to understand why and how the battery failed.

Suggested processes: Formalize authority for securing chain of custody, determine root cause using standardized procedures, and establish formal reporting mechanism for a battery or device involved in an aviation incident. Exceptions for incidents with an obvious non-design or construction flaw (e.g., crushed by fork lift) may be provided.

Why is this necessary? Airlines rarely have the ability to conduct a forensic or root cause analysis and may not have the authority to secure custody of the incident battery or device. A forensic evaluation and root cause analysis are important to determine why batteries fail. The results influence further safety improvements in design, manufacturing, and transportation safety regulatory requirements.

Additional items to consider: This process could be instituted statutorily or through departmental policy, assigned to PHMSA or FAA.

3. **Define all necessary supply chain data and information relevant to aviation to ensure or improve transportation safety, including the optimal means to store, access, and deliver this accurate and verifiable information.**

Current process for providing and validating relevant supply chain safety data: Currently, information available to airlines to verify supply chain integrity and quality management practices is limited. Airlines must rely on shipper integrity and verification of compliance with packaging standards through package markings and shipper documentation.

Suggested process: Moving forward, the Supply Chain Safety and Integrity Sub-Committee is undertaking a phased approach to their work:

1. Examine and define the supply chain/battery life-cycle process. Specifically, identifying key elements of the product lifecycle including design, development, manufacturing, distribution, use, repairs and recalls, and end of life (repurposing, disposal, resource recovery).
2. Assess best practices or principles in quality management/conformity assessment and identify safety processes that apply across the supply chain.
3. Document current information baseline available and provided to end users.
4. Identify requisite data set required by the aviation sector to validate safety and compliance, risk assessment, and emergency response procedures.

Why is this necessary? Generally, regardless of the product being developed, supply chains and lifecycle follow universal and sequential steps. Cases of non-compliance can often be traced back to the product development cycle. This Sub-Committee plans to take a similar, scientific approach to its work. However, this Sub-Committee will undertake its work with the recognition that documentation and information related to product design, manufacturing and quality control is developed and maintained by world-class organizations.

Additional items to consider: The Sub-Committee will work with the Data Collection Analysis and Regulations and Gap Analysis Sub-Committees for bidirectional input. This input will support the Sub-Committee's goal of identifying all necessary supply chain data and information relevant to aviation, to ensure or improve transportation safety, and to determine the optimal means to store, access, and deliver this accurate and verifiable information.

4. **Engage with battery manufacturers and the aviation sector to better define the risk profile of batteries shipped in cargo compartments, and effectively implement adequate SMS principles.**

   Current process for effective implementation of SMS principles by United States airlines: An SMS approach and its potential benefits require greater analysis by the Sub-Committee. As previously noted ICAO Annex 6 Chapter 15 implementation of safety cargo risk assessments applicable to aircraft operators requirements have recently become applicable. Best practices for compliance are currently not widely known, and are generally applied differently by different aviation sector members.

   Suggested process: At the September 2020 meeting, PHMSA Administrator Elliott remarked, "Wide spread implementation of, and sustained adherence to, a properly structured and administrated safety management system is the most likely way to arrive at zero incidents." This sentiment is shared throughout the government and international organizations, as ICAO and FAA are working to implement safety management systems. An SMS approach and its potential benefits require greater analysis by the Sub-Committee and, as such, the Sub-Committee identified two areas that it will focus on in the coming months.

   1. Understand and assess the impacts of ICAO Annex 6 Chapter 15 and FAA SMS mandates on air operators. The Hazard Review and Risk Mitigation Sub-Committee's purpose is to support the activities of the three main sub-committees. Considering the Sub-Committee's focus on SMS and ICAO Annex 6 Chapter 15, the Sub-Committee will reconvene for an educational series with ICAO and FAA on the implementation of these programs to ensure committee members are well versed in these SMS principles.

   2. Provide an overview by aircraft manufacturers of their risk assessments for batteries shipped as cargo in cargo compartments. Engage with manufacturers to review and analyze risk assessment, and share best practices for batteries shipped in cargo compartments.

   Why is this necessary? ICAO Annex 6 Chapter 15 will require operators to conduct a specific safety risk assessment that must include the safety of the supply chain. As such, ICAO Annex 6 will have an impact on both the airlines carrying and the manufacturers shipping batteries.

   Additional items to consider: During the September 2020 meeting, the complexity of the transport regulatory provisions was discussed and as a result, the Regulations and Gap Analysis Sub-Committee will examine paths to simplify regulatory provisions, while maintaining a high level of safety. Also discussed were undeclared and mis-declared shipments, and the importance of identifying best practices from freight forwarders and carriers to limit these shipments. The Sub-Committee will also identify regulatory gaps that

do not support air operators in accomplishing the ICAO Annex 6 Chapter 15 mandate and provide recommendations to eliminate identified gaps.

1. Assess current domestic and international regulatory provisions and identify opportunities for simplification, clarity, and enhanced safety.
2. Examine and discuss ways to improve communication and cooperation between competent authorities to enforce lithium battery dangerous goods regulations.
3. Identify best practices from freight forwarders and carriers to limit undeclared/mis-declared shipments.

Conclusion

At the September 2020 meeting, Secretary Elaine L. Chao and PHMSA Administrator Howard Elliott indicated that lithium battery safety continues to be one of the highest priorities for the Department. Our goal is to assist DOT and PHMSA leadership in this pursuit. Thank you for your commitment to lithium battery transportation safety. The Committee stands by to provide additional information, as needed and looks forward to continuing its work, as mandated by the FAA Reauthorization Act of 2018.

Addendum 1 – Member List

The following individuals have been appointed to the Lithium Battery Air Safety Advisory Committee. Bios for the appointees can be found here.

Name	Organization	Representative Category
Captain Bob Brown	Coalition of Airline PilotsAssociations	Pilots and Employees of Air ServiceProviders
Dr. J. Thomas Chapin	Underwriters Laboratories	Testing and Quality Assurance Verification
James Davis	AccuFleet Testing	Passenger Air Service Providers
Raju Desai	Apple	Manufacturer of Consumer Products
Doug Ferguson	Boeing	Manufacturer of Vehicles
Richard Hill	Federal Aviation Administration	Alternate Designated Federal Officer, Department of Transportation
George Kerchner	PRBA - The Rechargeable BatteryAssociation	Large Volume Manufacturer
Jennifer Littenberg	Hawaiian Airlines	Passenger Air Service Providers
Todd Mackintosh	General Motors	Manufacturer of Vehicles
Brandon Martin	Outdoor Power EquipmentInstitute	Manufacturer of Consumer Products
Robert McClelland	UPS Airlines	Cargo Air Service Providers
Kathleen O'Shei	Integer	Medical Devices
Duane Pfund	Pipeline and Hazardous Materials Safety Administration	Designated Federal Officer, Department of Transportation
William Reese	Commercial Vehicle SafetyAlliance	Highway Safety
Paul Rogers	International Association of FireFighters	Emergency Response
Stephane Rossetti	Medtronic	Shippers
Captain Scott Schwartz	Air Line Pilots AssociationCaptain	Pilots and Employees of Air ServiceProviders
Tim Sheppard	Samsung Electronics America	Manufacturer of Consumer Products
Philip Squair	National Electrical ManufacturersAssociation	Domestic Manufacturer
Michael Tobin	Alaska Airlines	Passenger Air Service Providers
David Weilert	Viking Packaging Specialist	Domestic Manufacturer
Veronica Wilson	Walmart	Marketers
Bill Wojtas*	United Airlines	Passenger Air Service Providers

**deceased*

Addendum 2 - Committee Leadership Bios

Captain Robert Brown, Coalition of Airline Pilots Associations, *Hazard Review and Risk Mitigation Sub-Committee*
Captain Bob Brown currently serves as Vice President of the Coalition of Airline Pilots Associations. He is a Boeing 757/767 Captain at UPS Airlines and a member of the Independent Pilots Association (IPA). Captain Brown has spent the last 20 years directly involved in advancing aviation safety. In his role as Chairman of the Lithium Battery Air Safety Advisory Committee, he leads a collaborative process between manufacturers, e-commerce platforms, airlines, and other industry stakeholders in providing recommendations to the DOT and Congress on safely transporting batteries on aircraft. Captain Brown's expertise have led to speaking opportunities in the United States, Canada, Europe, China, Singapore, and Japan. He has also conducted briefings for House and Senate Staff, and members of Congress on safety mitigation strategies. Captain Brown holds a BA in Communications from the University of Wisconsin - Milwaukee.

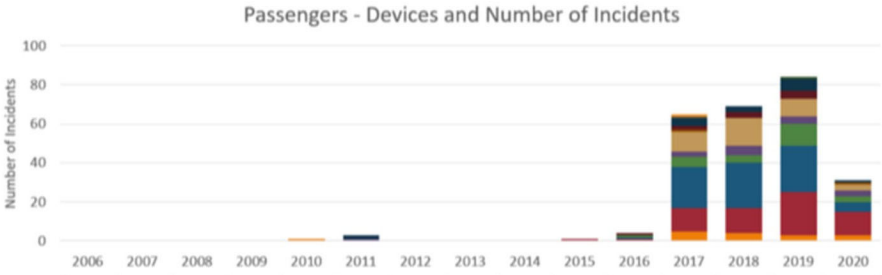
J. Thomas Chapin, Ph.D., Underwriters Laboratories, *Supply Chain Safety and Integrity Sub-Committee*
Dr. Tom Chapin is the Vice President, Research at Underwriters Laboratories Inc. He is a UL William Henry Merrill Society Corporate Fellow and past chairman of the UL Fire Council. Dr. Chapin currently focuses on emerging technologies, safety trends, aging, failure and forensic analysis, fire dynamics, and the "evolving" definition of safety. Previously, he managed UL corporate research activities related to UL standards, testing and certification, and surveillance services. Dr. Chapin has made over 300 technical presentations at conferences and has authored more than 150 technical publications in chemistry, materials, and polymer science. He is serving as an Adjunct Professor at Case Western Reserve University lecturing on chemistry, polymer science and fire dynamics. He received his BS in Chemistry with Honors from the University of Connecticut and a Ph.D. in Polymer Science from the Institute of Materials Science at the University of Connecticut.

Bob McClelland, UPS Airlines, *Data Collection and Analysis Sub-Committee*
Mr. Bob McClelland is the Managing Director of Safety and Dangerous Goods for UPS Airlines. He has more than 30 years with UPS. For over a decade, Mr. McClelland was solely responsible for the UPS Dangerous Goods Program. In 2017, he assumed responsibility for Airline Safety programs. Mr. McClelland has participated in industry and regulatory meetings around the world, most frequently speaking about the air transport of lithium batteries and UPS Airlines mitigation efforts for in-flight fires. He was a member of the Transportation Research Board's Dry Ice Study from 2008 to 2012. Mr. McClelland holds a BS in Business Administration from the University of Houston.

Michael Tobin, Alaska Airlines, *Regulations and Gap Analysis Sub-Committee*
Mr. Michael Tobin serves as the Senior Dangerous Goods Manager for Alaska Airlines. He has responsibility for allaspects of the regulations and safety risks pertaining to hazardous materials, including lithium batteries in air transportation. Mr. Tobin is a Certified Hazardous Materials Manager, a Member on the IATA Dangerous Goods Board, a voting member of the SAE G-27, and UL Standards 5800 Technical Panel. Mr. Tobin served on the PHMSA-FAA Hazmat Aviation Rulemaking Committee for Passenger Notification of Hazardous Materials Regulations. He holds a BS in Business Administration from theUniversity of Portland.

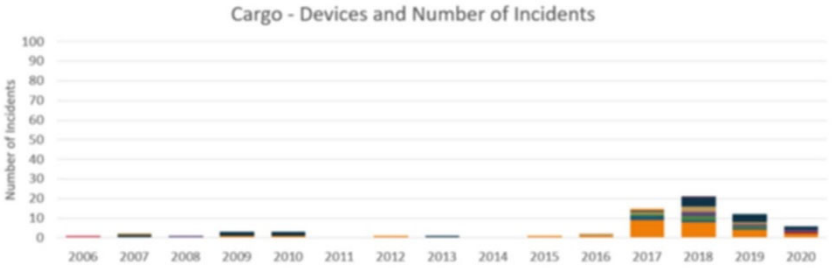
Addendum 3 – TRIP Data

Figure 1 – Passenger: Devices and Number of Incidents



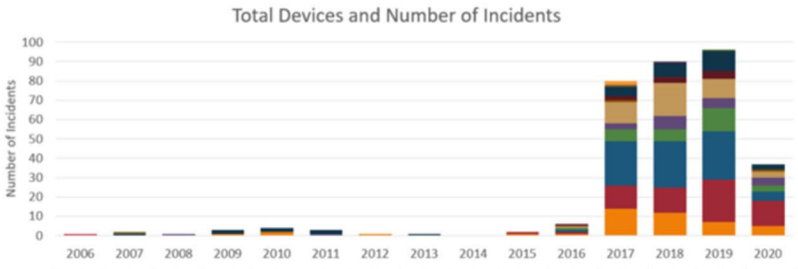
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Flashlight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium metal Battery	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Lithium-polymer Battery	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Medical device	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wheelchair	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lithium battery (unknown)	0	0	0	0	0	2	0	0	0	0	0	4	3	6	1
Tablet	0	0	0	0	0	0	0	0	0	0	1	2	3	4	0
Camera	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Cell Phone	0	0	0	0	0	0	0	0	0	0	0	10	14	9	3
Other	0	0	0	0	0	1	0	0	0	0	0	3	5	4	3
Laptop	0	0	0	0	0	0	0	0	0	0	1	5	4	11	3
Power bank / Battery charger	0	0	0	0	0	0	0	0	0	0	1	21	23	24	5
e-Cigarette (vape pen, electronic cigarette, vaping device)	0	0	0	0	0	0	0	0	0	1	1	12	13	22	12
Lithium-ion Battery	0	0	0	0	1	0	0	0	0	0	0	5	4	3	3

Figure 2 – Cargo: Devices and Number of Incidents



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Flashlight	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium metal Battery	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Lithium-polymer Battery	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Medical device	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Wheelchair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium battery (unknown)	0	1	0	2	2	0	0	1	0	0	0	1	4	4	2
Tablet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cell Phone	0	0	0	0	0	0	0	0	0	0	1	1	3	1	0
Other	0	0	1	0	0	0	0	0	0	0	0	0	2	1	1
Laptop	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0
Power bank / Battery charger	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0
e-Cigarette (vape pen, electronic cigarette, vaping device)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lithium-ion Battery	0	0	0	1	1	0	1	0	0	1	1	9	8	4	2

Figure 3: Total Devices and Number of Incidents



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Flashlight	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium metal Battery	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Lithium-polymer Battery	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Medical device	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Wheelchair	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lithium battery (unknown)	0	1	0	2	2	2	0	1	0	0	0	5	7	10	3
Tablet	0	0	0	0	0	0	0	0	0	0	1	2	3	4	0
Camera	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Cell Phone	0	0	0	0	0	0	0	0	0	0	1	11	17	10	3
Other	0	0	1	0	0	1	0	0	0	0	0	3	7	5	4
Laptop	0	0	0	0	0	0	0	0	0	0	1	6	6	12	3
Power bank / Battery charger	0	0	0	0	0	0	0	0	0	0	1	23	24	25	5
e-Cigarette (vape pen, electronic cigarette, vaping device)	0	0	0	0	0	0	0	0	0	1	1	12	13	22	13
Lithium-ion Battery	0	0	0	1	2	0	1	0	0	1	1	14	12	7	5

Figure 4: Types of Data Gaps