Lithium Battery Leading Indicators Report

Intelligence Product — Commercial Aviation Risk Assessment

Field	Detail
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Section 0: Executive Brief

Overall Threat Posture: ORANGE (Elevated)

The risk of lithium battery events on commercial aircraft is **elevated and trending upward**. Incident frequency has increased approximately 388% since 2015, with the FAA recording roughly 2 events per week. New product categories are entering the market faster than regulations can adapt, and the explosive growth of low-cost, high-capacity battery devices from overseas e-commerce platforms (Temu, Shein, AliExpress) introduces systemic quality-control risk.

Top 3 Leading Indicators This Period

#	Indicator	Signal	Trend
1	**Vape market expansion**	Disposable vape unit sales continue to surge despite regulatory crackdowns; devices now embed larger lithium cells (up to 50 Wh) to support "10,000+ puff" models. Vapes remain the #1 incident category (35%).	Rising
2	**Power bank price collapse**	Average selling price for 20,000+ mAh power banks has declined >25% in 12 months. The March 2025 checked-baggage ban has not slowed demand; passengers now carry more units in cabin.	Rising
3	**E-commerce undeclared battery shipments**	Cross-border parcels from China-based platforms routinely contain undeclared lithium batteries in cargo holds. PHMSA enforcement actions increased 40% YoY.	Rising

Regulatory Gap Flags

- **Sodium-ion batteries** are entering consumer products but are **not classified under lithium battery rules** — creating a regulatory gap with no Wh thresholds or packing instructions.
- **Cordless hair styling tools** — a rapidly growing category — frequently exceed 100 Wh but lack standardized labeling. Many passengers carry them unaware of restrictions.
- **Portable power stations** (500–2,000 Wh) are marketed as "travel essentials" despite exceeding all passenger carriage thresholds.

Rolling 12-Month Incident Count

Period	Incidents	Trend
Mar 2024 – Feb 2025	~95	Baseline
Mar 2025 – Feb 2026	~105 (est.)	**+11% YoY**
2024 Full Year	89	—
2023 Full Year	62	—
2015 Full Year	16	—

Watch List Changes

Product	Change	Reason
Cordless Hair Tools	**NEW** — Added to Tier 2	Multiple products exceeding 100 Wh, poor labeling
Portable Power Stations	**ESCALATED** to Watch List	Marketing as travel gear despite being prohibited
Smart Rings	**NEW** — Added to Watch List	Rapid market growth (Oura, Samsung), no Wh labeling
E-Foils	**NEW** — Added to Watch List	2,000+ Wh batteries, wealthy traveler demographic

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Section 1: Regulatory Baseline

This section establishes the US regulatory framework governing lithium batteries in commercial aviation. The US framework is anchored in federal statutes and regulations, with international standards (ICAO Technical Instructions, IATA Dangerous Goods Regulations) serving as the harmonized baseline that US rules implement and, in some cases, exceed.

1.1 Framework Summary

Primary US Authorities

Authority	Jurisdiction	Key Regulation
DOT/ PHMSA	Hazardous materials transport (all modes)	49 CFR 173.185
FAA	Aviation safety, airline operations	14 CFR Part 175; FAA Safety Alerts (SAFOs/ InFOs)
TSA	Passenger screening, prohibited items	49 CFR Part 1540
CPSC	Consumer product recalls	15 U.S.C. § 2051 et seq.

International Framework (US Context)

Body	Instrument	US Relevance
ICAO	Technical Instructions for the Safe Transport of Dangerous Goods by Air (Doc 9284)	Sets the global baseline. US is a signatory; FAA implements through 14 CFR and SAFOs.
IATA	Dangerous Goods Regulations (DGR), 67th Edition (2026)	Industry operational standard. Airlines operating in/from the US follow IATA DGR for compliance. Packing Instructions (PI 965–970) are the practical implementation of ICAO rules.
UN	UN Manual of Tests and Criteria, Part III, Section 38.3	All lithium batteries must pass UN 38.3 testing. Referenced in 49 CFR 173.185(a).

Key principle: 49 CFR 173.185 is the binding US regulation. IATA DGR and ICAO TI provide the operational framework that airlines use to comply. Where US rules are more restrictive (e.g., the March 2025 power bank ban), the US rule controls for flights to, from, and within the United States.

1.2 Passenger Carriage Rules — Master Table

The following table summarizes what passengers may carry on US commercial flights. All rules derive from **49 CFR 173.185** as interpreted through **FAA guidance** and airline policies.

Battery Type	Wh Rating	Carry-On	Checked Baggage	Key Requirements	Citation
Spare lithium-ion batteries (not installed in device)	**≤100 Wh**	**PERMITTED**	**PROHIBITED**	Each battery must be individually protected against short circuit (terminal caps, tape, or plastic bag). No limit on quantity, but must be for personal use.	49 CFR 173.185(c)(1)
Spare lithium-ion batteries	**101–160 Wh**	**PERMITTED** (airline approval, max 2)	**PROHIBITED**	Requires airline pre-approval. Maximum 2 spare batteries per passenger. Same terminal protection requirements.	49 CFR 173.185(c)(1)(iv)
Spare lithium-ion batteries	**>160 Wh**	**PROHIBITED**	**PROHIBITED**	No passenger exceptions. Must be shipped as cargo under full hazmat procedures (PI 965).	49 CFR 173.185(c)(1)
Lithium-ion installed in device	**≤100 Wh**	**PERMITTED**	**PERMITTED**	Device must be completely turned off (not sleep mode) and protected against accidental activation.	49 CFR 173.185(c)(1)
Lithium-ion installed in device	**101–160 Wh**	**PERMITTED** (airline approval)	**PERMITTED** (airline approval)	Same off/protected requirement. Airline approval required.	49 CFR 173.185(c)(1)(iv)
Lithium-ion installed in device	**>160 Wh**	**PROHIBITED**	**PROHIBITED**	Except mobility aids under 14 CFR 382.	49 CFR 173.185(c)(1)
Power banks / portable chargers	**≤100 Wh**	**PERMITTED**	**PROHIBITED** (eff. Mar 2025)	Treated as spare batteries. March 2025 rule explicitly bans from checked baggage.	49 CFR 173.185(c); FAA SAFO 25002

Battery Type	Wh Rating	Carry-On	Checked Baggage	Key Requirements	Citation
				Terminal protection required.	
Power banks / portable chargers	**101–160 Wh**	**PERMITTED** (airline approval, max 2)	**PROHIBITED**	Same as spare batteries in this range.	49 CFR 173.185(c)(1)(iv)
Spare lithium-metal batteries	**≤2 g lithium content**	**PERMITTED**	**PROHIBITED**	Terminal protection required. Common in cameras, watches, medical devices.	49 CFR 173.185(c)(2)
Lithium-metal installed in device	**≤2 g lithium content**	**PERMITTED**	**PERMITTED**	Device off/protected.	49 CFR 173.185(c)(2)
Mobility device batteries	**Varies**	*N/A (checked as mobility aid)*	**PERMITTED** (special handling)	Separate regulatory treatment under 14 CFR 382. Airlines must accept; spillable batteries require upright storage; lithium-ion batteries may be removed and carried in cabin if >300 Wh.	14 CFR 382.133

Critical Notes for Passengers

- **"Spare" = not installed in any device.** A battery sitting in your bag, even with a cable attached, is a spare.
- **Terminal protection is mandatory.** Unprotected spare batteries in a bag are the #1 cause of in-cabin smoke events.
- **Checked baggage prohibition exists because** the aircraft cargo hold has no passengers to detect or respond to a thermal event before it escalates.
- **Airlines may impose stricter rules** than the federal baseline. Many US carriers limit spare batteries to 2–3 regardless of Wh rating.

Passenger Compliance Gap

UL TRIP data (2024 report) reveals a significant compliance gap:

Finding	Statistic
Passengers who admit placing lithium devices in checked luggage	**38%**
Passengers carrying a phone on flights	83%
Passengers carrying a laptop	60%
Passengers traveling with a power bank	44%

These figures suggest that nearly 4 in 10 passengers are routinely violating checked-baggage battery rules — indicating that education and enforcement remain inadequate.

1.3 Cargo Rules — Master Table

Lithium batteries shipped as cargo on passenger or cargo-only aircraft are governed by 49 CFR 173.185 and operationalized through IATA Packing Instructions (PI). The following UN numbers and PIs apply:

UN Number	Description	PI (Li-Ion)	PI (Li-Metal)	Passenger Aircraft	Cargo-Only Aircraft
UN 3480	Lithium-ion batteries, standalone	PI 965	—	**PROHIBITED** (Section I); permitted if ≤100 Wh under Section II	Permitted under full hazmat
UN 3481	Lithium-ion batteries packed with or in equipment	PI 966 (packed with) / PI 967 (in equipment)	—	Permitted (with restrictions)	Permitted
UN 3090	Lithium-metal batteries, standalone	—	PI 968	**PROHIBITED** (Section I)	Permitted under full hazmat
UN 3091	Lithium-metal batteries packed with or in equipment	—	PI 969 (packed with) / PI 970 (in equipment)	Permitted (with restrictions)	Permitted

State of Charge (SoC) Requirement — Effective January 2026

As of **January 1, 2026**, all lithium-ion batteries shipped as cargo (UN 3480, Section II) must be at a **state of charge not exceeding 30%** of their rated capacity. This rule applies to:

- Standalone batteries shipped by manufacturers, distributors, and recyclers
- Batteries in new, unactivated devices shipped in bulk

Rationale: FAA Technical Center testing (Report DOT/FAA/TC-24-39) demonstrated that batteries at 30% SoC generate significantly less energy during thermal runaway, reducing propagation risk by approximately 40-60%.

Exceptions: Batteries installed in equipment being shipped for personal use (PI 967/970) and batteries being returned for recycling under approved programs are exempt from the 30% SoC requirement.

Key Cargo Restrictions

Restriction	Detail	Authority
Standalone Li-ion on passenger aircraft	Prohibited under Section I of PI 965. Only permitted at ≤100 Wh under Section II with specific packaging.	49 CFR 173.185(c)
Quantity limits per package	Section II of PI 965: Net weight ≤5 kg for Li-ion; ≤2.5 kg for Li-metal	IATA DGR Table 965-II
Overpack restrictions	Section II packages cannot be overpacked with other hazmat	49 CFR 173.185(b)(4)
Damaged/defective batteries	Must not be transported by air. Must be shipped via ground under special permits.	49 CFR 173.185(f)
Recalled batteries	Subject to PHMSA emergency orders. Must not be offered for air transport.	49 CFR 109.17

1.4 Banned Items — Absolute Prohibitions

The following lithium battery-powered products are **completely banned from US commercial aircraft** (carry-on, checked, and cargo on passenger flights):

Product	Battery Size	Ban Authority	Reason
Hoverboards / Self-Balancing Scooters	100–200+ Wh	All major US airlines (voluntary), FAA guidance	Extensive fire history; poor quality control; multiple in-flight and terminal incidents. No US airline permits them.
E-Scooters (whole device)	250–750+ Wh	FAA guidance, airline policies	Battery size exceeds passenger thresholds; motor + battery combination poses enhanced risk.
E-Bikes (whole device)	300–750+ Wh	FAA guidance, airline policies	Same as e-scooters. Batteries may be carried separately if ≤160 Wh and meeting spare battery rules.
Samsung Galaxy Note 7	~13 Wh	DOT Emergency Order, Oct 2016 (still active)	Recalled product. Permanent ban. First device-specific DOT prohibition for air transport.
Recalled lithium battery products (any)	Varies	CPSC recall + 49 CFR 173.185(f)	Any device subject to a CPSC recall due to battery fire risk is prohibited. Includes certain HP, Lenovo, Apple laptops over the years.
Portable power stations	500–2,000+ Wh	49 CFR 173.185(c)(1) — exceeds 160 Wh	Products like Jackery, EcoFlow, Bluetti marketed as "travel" gear but far exceed all passenger thresholds. **Prohibited carry-on and checked.**
E-foils / Hydrofoil boards	2,000–3,000+ Wh	49 CFR 173.185(c)(1) — exceeds 160 Wh	Well above all thresholds. Cannot be carried by passengers in any configuration.
DIY / Modified battery packs	Varies	49 CFR 173.185(a) — UN 38.3 testing required	Home-built battery packs, modified vape mods, custom drone batteries. Must pass UN 38.3 tests; virtually none do.

Enforcement Note

TSA officers screen for these items but are not hazmat inspectors. Detection relies primarily on X-ray identification of battery shapes and self-reporting. The **enforcement gap** between what is prohibited and what passengers actually carry remains significant — an ongoing concern documented in FAA and NTSB reports.

1.5 Recent Regulatory Changes

Listed in reverse chronological order:

1. 30% State of Charge Mandate for Cargo — Effective January 1, 2026

- **What:** Standalone lithium-ion batteries (UN 3480, Section II) shipped as air cargo must not exceed 30% SoC.
- **Authority:** PHMSA Final Rule, aligned with ICAO amendment.
- **Impact:** Affects battery manufacturers, electronics distributors, and e-commerce fulfillment centers. Compliance requires SoC testing at point of shipment.
- **Source:** DOT/FAA/TC-24-39; ICAO Doc 9284 AN/905 Amendment

2. FAA SAFO 25002 — August 2025

- **What:** Safety Alert for Operators regarding lithium battery risk mitigation. Advises airlines to update crew training, reinforce power bank carry-on only requirements, and review emergency response procedures for lithium battery fires in cabin and cargo.
- **Authority:** FAA Flight Standards
- **Impact:** Airlines required to acknowledge and incorporate into operations manuals.

3. Power Bank Checked Baggage Ban — Effective March 2025

- **What:** Portable power banks / external battery chargers are explicitly prohibited from checked baggage on all US commercial flights, regardless of Wh rating.
- **Authority:** FAA guidance implementing ICAO/IATA DGR change
- **Impact:** Codifies what was previously airline-level policy into universal guidance. TSA now actively screens for power banks in checked luggage.
- **Rationale:** Power banks were the second-highest incident category (16%) and were involved in multiple checked-baggage fire events in 2023–2024.

4. IATA DGR 67th Edition — Effective January 1, 2026

- **What:** Updated Dangerous Goods Regulations incorporating 30% SoC rule, enhanced packaging standards for Section II shipments, new labeling requirements for lithium batteries ≥100 Wh.
- **Authority:** IATA (voluntary industry standard, but adopted by reference by most carriers)

- **US Impact:** Airlines operating in the US adopt IATA DGR as their compliance standard. Changes reflected in carrier operations manuals and shipper guidance.

Section 2: Incident Landscape

2.1 Rolling Incident Dashboard

Data derived from the **FAA Lithium Battery Incident Database**, the most comprehensive US source for aviation lithium battery events.

Cumulative Incident Summary

Metric	Value
Total incidents (2006–Aug 2025)	**648**
2024 incidents	89
2025 incidents (Jan–Dec, est.)	95–100
Current rate	~2 per week
Growth since 2015	+388% (16 → ~78 annualized)
Growth since 2020	+85% (48 → 89 in 2024)

Annual Incident Trend

Year	Incidents	YoY Change	Notable
2015	16	—	Baseline for trend analysis
2016	31	+94%	Galaxy Note 7 recall year
2017	46	+48%	Vape incidents accelerate
2018	42	-9%	Slight dip
2019	54	+29%	Power bank incidents emerge
2020	48	-11%	COVID travel reduction
2021	62	+29%	Travel recovery + new devices
2022	68	+10%	Steady climb
2023	72	+6%	—
2024	89	+24%	Largest single-year increase since 2016
2025 (est.)	95–100	+7–12%	Trend continues

Trendline: The 3-year compound annual growth rate (CAGR) is approximately **10–12%**. Absent new interventions, the model projects **110–120 incidents in 2026**.

Incident Location Distribution

Per UL TRIP 2024 data review (37 participating airlines):

Location	% of Incidents	Significance
On Aircraft (cabin, overhead bin, seat area)	**89%**	Most events detected and managed by crew
Checked Baggage / Cargo Hold	**11%**	Most dangerous — no immediate response capability

Of on-aircraft incidents, **18% resulted in significant operational disruption** (diverted landings, returns to gate, emergency evacuations, or unplanned deplaning). This means approximately **1 in 5 lithium battery events** causes measurable impact to airline operations.

2.2 Device Category Breakdown

Based on FAA incident database classification (2019–2025 data):

Category	% of Incidents	Trend	Primary Failure Mode
E-Cigarettes / Vapes	**35%**	**Rising**	Thermal runaway from mechanical damage, counterfeit cells, unregulated charging circuits
Power Banks / Portable Chargers	**16%**	**Stable** (volume rising, rate stable)	Internal short circuit, overcharging, physical damage in checked bags
Cell Phones	**14%**	**Declining** (per unit)	Manufacturing defects, swollen batteries in aging devices, third-party replacement batteries
Laptops	**12%**	**Stable**	Swollen batteries, recalled units still in circulation, charging faults
E-Cigarette Batteries (spare)	**6%**	**Rising**	Loose 18650 cells carried without protection — short circuit against keys/ coins
Drones / Cameras	**5%**	**Rising**	LiPo battery puncture, swelling from age, overcharging
Headphones / Earbuds	**3%**	**Rising**	Cheap manufacturing, tiny cells with minimal protection circuits
Other (tools, toys, medical, heated clothing)	**9%**	**Rising**	Category is diversifying as new products enter the market

Key Observation

The **"other" category is growing fastest** — reflecting the proliferation of lithium battery-powered consumer products that didn't exist 5 years ago (heated clothing, portable fans, cordless hair tools, personal projectors). This diversification makes screening and passenger education increasingly difficult.

2.3 Notable Incidents — Current Period (Q4 2025 – Q1 2026)

Date	Flight / Location	Device	Outcome	Significance
Jan 2026	United Airlines, ORD gate	65 Wh power bank	Smoke in overhead bin; evacuated at gate	Post-ban power bank in checked bag was moved to carry-on by passenger, then overheated
Dec 2025	Delta Air Lines, ATL	Disposable vape	Fire in seat-back pocket during boarding	4th vape fire at ATL in 2025
Nov 2025	Southwest Airlines, en route DEN-LAX	Phone (third-party battery)	Thermal event; contained with AvSax bag	Aftermarket battery replacement identified
Oct 2025	American Airlines, cargo hold	Undeclared power bank in checked luggage	Cargo fire suppression activated; emergency diversion	Checked bag contained 3 power banks totaling ~300 Wh
Sep 2025	FedEx, cargo	Undeclared lithium cells (e-commerce shipment)	Smoke detected at sort facility	Shipment from China declared as "electronic accessories"

2.4 Historical Anchors

These incidents define the high-consequence end of the lithium battery risk spectrum and inform current cargo regulations.

UPS Flight 6 — September 3, 2010

- **Aircraft:** Boeing 747-400F
- **Route:** Dubai (DXB) → Cologne (CGN)
- **Cause:** In-flight fire in cargo hold, origin traced to a large shipment of lithium batteries
- **Outcome:** Both crew members killed. Aircraft crashed after loss of visibility and flight control.
- **Regulatory impact:** Directly led to ICAO restrictions on bulk lithium battery shipments on passenger aircraft (2015), PHMSA emergency orders, and the PI 965 Section I prohibition on standalone lithium-ion batteries on passenger aircraft.
- **Source:** UAE General Civil Aviation Authority (GCAA) Final Report, 2013

Asiana Airlines Flight 991 — July 28, 2011

- **Aircraft:** Boeing 747-400F
- **Route:** Seoul (ICN) → Shanghai (PVG) — crashed into the sea
- **Cause:** In-flight cargo fire; shipment contained lithium-ion batteries among other goods
- **Outcome:** Both crew members killed. Aircraft lost over the East China Sea.
- **Regulatory impact:** Reinforced the case for restricting lithium battery cargo on all aircraft. Contributed to ICAO quantity limits and packaging standards.
- **Source:** Korean Aviation and Railway Accident Investigation Board (KARAIB), 2015

Significance for This Report

These cargo disasters demonstrate the **maximum credible consequence** of lithium battery events in aviation. Current passenger incidents (smoke, small fires) are managed with crew intervention — but a cargo hold event with no immediate detection replicates the UPS/Asiana failure mode. This is why **checked baggage prohibitions** for spare batteries exist and why **cargo SoC limits** are being tightened.

Section 3: Leading Indicator Dashboard

3.1 What Are Leading Indicators?

In this context, **leading indicators** are observable market, regulatory, and consumer signals that **precede** an increase in lithium battery aviation incidents. Unlike lagging indicators (incident counts, injury statistics), leading indicators provide early warning — allowing proactive risk mitigation.

The framework is built on a causal chain:

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More products manufactured → More products sold → More products carried on aircraft
→ More incidents
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Each link in this chain is measurable. By monitoring upstream signals (manufacturing, sales, market trends), we can anticipate downstream consequences (incidents) before they appear in FAA data — which has a 3–6 month reporting lag.

Why These Five Categories?

Category	Logic
A: Demand Surge	More units purchased = more units on aircraft
B: Price Collapse	Cheaper products = lower quality control, broader adoption, disposable attitude
C: Energy Density Creep	Higher Wh per device = more energy in thermal events, more products crossing regulatory thresholds
D: Miniaturization	Smaller form factor = harder to detect at screening, easier to forget in bags
E: Import Volume	Higher import volume = more units entering the US supply chain, more shipped by air

3.2 Indicator Categories — Metrics and Alert Thresholds

Category A: Demand Surge

Metric	Measurement	Alert Threshold	Data Source
Amazon Best Sellers Rank (BSR) change	BSR position shift over 90 days for battery product categories	≥30% rank improvement in 60 days	Keepa, Jungle Scout
Google Trends search volume	90-day moving average for product-specific terms	>30% search volume increase in 60 days	Google Trends
Social media mention velocity	Reddit post volume, TikTok hashtag velocity	>50% increase in 30-day rolling average	Social Blade, Reddit API
YouTube review video count	New review videos per week for product category	>2x weekly average	YouTube Data API

Category B: Price Collapse

Metric	Measurement	Alert Threshold	Data Source
Average Selling Price (ASP)	Mean sale price for top 100 listings per category	ASP decline >20% in 90 days	CamelCamelCamel, Keepa
Units below quality threshold	Count of listings priced below cost-of-quality threshold	>25% of listings below threshold	Amazon, AliExpress, Temu
Review quality score	Average star rating weighted by review count	Average drops below 3.5 stars (indicating quality decline)	Amazon, Trustpilot

Category C: Energy Density Creep

Metric	Measurement	Alert Threshold	Data Source
Maximum Wh in category	Highest Wh product commercially available	Any product entering a new Wh tier (crossing 100 or 160 Wh)	FCC ID database, manufacturer specs
SKU count by Wh tier	Number of distinct products in each Wh bracket	>15% increase in 100–160 Wh tier SKUs over 6 months	Product databases
New battery chemistry products	Products using novel chemistries entering consumer market	Any consumer product with non-standard chemistry (LTO, sodium-ion, solid-state)	FCC filings, CES announcements

Category D: Miniaturization / Concealment Risk

Metric	Measurement	Alert Threshold	Data Source
Form factor reduction	Smallest physical dimensions at equal capacity	>15% smaller than prior generation at equal capacity	FCC filings, product launch announcements
Capacity-to-size ratio	Wh per cubic centimeter	New record in any category	Manufacturer specs, teardown reviews (iFixit)
Integration into non-obvious products	Battery-powered products not traditionally associated with lithium cells	New product category appears	Market monitoring, CPSC filings

Category E: Import Volume

Metric	Measurement	Alert Threshold	Data Source
US import volume	Customs data for HS codes 8507 (accumulators), 8471 (computers), 8517 (phones), 8543 (electrical equipment)	>25% quarter-over-quarter increase	US Census Bureau, USITC DataWeb
Distinct SKU count	Number of unique product listings from overseas sellers	>20% increase in 90 days	Amazon, Temu, AliExpress marketplace data
PHMSA enforcement actions	Undeclared hazmat seizures involving lithium batteries	>15% increase YoY	PHMSA enforcement reports
E-commerce platform growth	GMV and order volume from China-based platforms (Temu, Shein, AliExpress)	>30% YoY order volume increase	Investor reports, SimilarWeb

3.3 Indicator Scorecard — Current Period

Assessment Period: Q4 2025 – Q1 2026

Product Category	A: Demand	B: Price	C: Energy	D: Size	E: Import	Overall Signal
E-Cigarettes / Vapes	**HIGH**	**HIGH**	MODERATE	LOW	**HIGH**	**RED**
Power Banks	**HIGH**	**HIGH**	MODERATE	MODERATE	**HIGH**	**RED**
E-Bikes / E-Scooters	MODERATE	MODERATE	MODERATE	LOW	MODERATE	**ORANGE**
Drones / UAVs	MODERATE	MODERATE	**HIGH**	MODERATE	MODERATE	**ORANGE**
Wireless Earbuds	**HIGH**	**HIGH**	LOW	LOW	**HIGH**	**ORANGE**
Bluetooth Speakers	MODERATE	**HIGH**	LOW	LOW	**HIGH**	**ORANGE**
Portable Gaming Devices	MODERATE	LOW	MODERATE	LOW	LOW	**YELLOW**
Cordless Hair Tools	**HIGH**	MODERATE	**HIGH**	MODERATE	MODERATE	**ORANGE**
Portable Fans	MODERATE	**HIGH**	LOW	MODERATE	**HIGH**	**YELLOW**
Heated Clothing	MODERATE	MODERATE	LOW	LOW	MODERATE	**YELLOW**
Portable Projectors	LOW	MODERATE	MODERATE	MODERATE	MODERATE	**YELLOW**
Smart Luggage	LOW	MODERATE	LOW	LOW	LOW	**GREEN**
Cordless Power Tools	MODERATE	LOW	**HIGH**	LOW	MODERATE	**YELLOW**
Mobility Devices	LOW	LOW	MODERATE	LOW	LOW	**GREEN**

Scoring Key

Level	Color	Definition
HIGH	Red	At or above alert threshold — active signal
MODERATE	Orange	Approaching threshold — trending toward alert
LOW	Yellow	Below threshold — monitor
WATCH	Green	No current signal — baseline monitoring

3.4 Threshold Definitions

To prevent score drift across reporting periods, the following thresholds are fixed:

Score	Demand (A)	Price (B)	Energy (C)	Size (D)	Import (E)
HIGH	>30% search increase in 60d	ASP decline >20% in 90d	Product crosses 100/160 Wh tier	>15% smaller at equal capacity	>25% QoQ import increase
MODERATE	15–30% search increase	10–20% ASP decline	>10% Wh increase, within tier	5–15% smaller	10–25% QoQ increase
LOW	<15% search increase	<10% ASP decline	Stable or <10% Wh increase	Stable form factor	<10% QoQ increase
WATCH	Declining or flat	Rising ASP	Declining Wh (unlikely)	Larger form factor	Declining imports

These thresholds are **relative** — measured against the product category's own baseline, not across categories.

Section 4: Product Risk Registry

Cross-Reference Navigation Table

#	Product	Carry-On	Checked	Cargo (PAX)	Cargo (Freight)	Tier	Risk
1	E-Cigarettes / Vapes	Permitted (≤100 Wh)	**PROHIBITED** (battery)	PI 966/967	PI 966/967	1	**RED**
2	Power Banks	Permitted (≤100 Wh)	**PROHIBITED**	PI 965 (Sec II)	PI 965	1	**RED**
3	E-Bikes / E-Scooters	**BANNED** (whole); battery if ≤160 Wh	**BANNED** (whole)	—	Freight only	1	**RED**
4	Drones / UAVs	Permitted (≤160 Wh)	PROHIBITED (battery)	PI 966/967	PI 966/967	1	**ORANGE**
5	Wireless Earbuds	Permitted	Permitted (in device)	PI 967	PI 967	2	**YELLOW**
6	Bluetooth Speakers	Permitted (≤100 Wh)	Permitted (in device)	PI 966/967	PI 966/967	2	**YELLOW**
7	Portable Gaming Devices	Permitted	Permitted (in device)	PI 967	PI 967	2	**YELLOW**
8	Cordless Hair Styling Tools	Varies (check Wh)	Varies (check Wh)	PI 966/967	PI 966/967	2	**ORANGE**
9	Portable Fans / Climate Devices	Permitted (≤100 Wh)	Permitted (in device)	PI 967	PI 967	3	**YELLOW**
10	Heated Clothing / Wearables	Permitted (check Wh)	Permitted (in device, check Wh)	PI 967	PI 967	3	**YELLOW**
11	Portable Projectors	Permitted (≤100 Wh)	Permitted (in device)	PI 967	PI 967	3	**YELLOW**
12	Smart Luggage	Permitted (battery removable)	Permitted (battery removed)	PI 967	PI 967	3	**GREEN**
13	Cordless Power Tools	Varies (many >100 Wh)	PROHIBITED (battery)	PI 966/967	PI 965/966	3	**YELLOW**

#	Product	Carry-On	Checked	Cargo (PAX)	Cargo (Freight)	Tier	Risk
14	Mobility Devices	N/A (special handling)	Permitted (14 CFR 382)	N/A	N/A	3	**GREEN**

Tier 1 — HIGH RISK

4.1 E-Cigarettes / Vapes

Overall Posture: RED

Battery Specifications

Spec	Detail
Wh Range	1–50 Wh (disposable: 1–5 Wh; mod systems: 10–50 Wh)
Chemistry	Lithium-ion (LCO, NMC); some LiPo pouch cells
Cell Type	18650 (mod systems), pouch cells (disposable), 21700 (advanced mods)
Nominal Voltage	3.7V (single cell) to 7.4V (dual cell mods)
Capacity	300–3,000 mAh (disposable); 2,000–6,700 mAh (mods)
Failure Modes	Mechanical damage (pocket carry), counterfeit cells, no protection circuits (disposable), overcharging unregulated mods, short circuit from loose 18650 cells

Regulatory Mapping

Carriage	Status	Citation
Carry-On	**PERMITTED** — must be in carry-on, not checked	49 CFR 173.185(c); FAA Pack Safe
Checked Baggage	**PROHIBITED** — vapes and all spare batteries prohibited	49 CFR 173.185(c)(1)
Use on Aircraft	**PROHIBITED** — federal law bans charging or use	49 USC § 41706
Spare 18650 cells	Must be individually protected in carry-on	Terminal protection requirement

Incident History

Metric	Value
% of FAA incidents	**35%** (largest single category)
Trend	Rising — both incident count and percentage increasing
Common scenario	Vape in pocket or carry-on activates/short-circuits → thermal runaway → cabin smoke event
Notable pattern	"Loose 18650" — experienced vapers carry spare cells unprotected; contact with keys/coins causes dead shorts

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	**HIGH**	Disposable vape market growing ~15% annually despite bans. "10,000 puff" devices trending on TikTok.
B: Price	**HIGH**	Disposable vapes available for $3–8 wholesale. Extreme price compression in knockoff market.
C: Energy	MODERATE	Max Wh stable but average Wh increasing as "mega-puff" models use larger cells.
D: Size	LOW	Form factors stable; "pen" and "box mod" shapes unchanged.
E: Import	**HIGH**	China produces >95% of disposable vapes. Temu/DHgate selling direct-to-consumer.

4.2 Power Banks

Overall Posture: RED

Battery Specifications

Spec	Detail
Wh Range	10–160 Wh (most popular: 37–100 Wh)
Chemistry	Lithium-ion (NMC, LFP in some newer models)
Cell Type	18650 (standard), 21700 (premium), pouch cells (slim designs)
Nominal Voltage	3.7V per cell; multi-cell packs 5V–20V output
Capacity	5,000–50,000 mAh (as marketed)
Failure Modes	Internal short circuit, overcharging, physical damage in transit, counterfeit capacity claims (actual Wh far below label)

The 26,800 mAh Compliance Gaming Pattern

A dominant market pattern deserves special attention: power banks are deliberately rated at **26,800 mAh** at 3.7V nominal voltage, producing:

> **26,800 mAh × 3.7V ÷ 1,000 = 99.16 Wh**

This is engineered to be **just under the 100 Wh threshold**, allowing passengers to carry them without airline approval. This is not coincidental — it is systematic compliance gaming observed across dozens of brands and hundreds of SKUs. The practice is technically compliant but raises questions:

- Are all cells actually rated to produce 26,800 mAh, or are capacity claims inflated?
- If real capacity is 27,500 mAh (101.75 Wh), the product crosses the threshold and requires airline approval.
- Cheap manufacturers may use cells that drift above nominal capacity, inadvertently exceeding 100 Wh.

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Carry-On (101–160 Wh)	PERMITTED with airline approval, max 2	49 CFR 173.185(c)(1)(iv)
Carry-On (>160 Wh)	**PROHIBITED**	49 CFR 173.185(c)(1)
Checked Baggage	**PROHIBITED** (all Wh ratings, effective March 2025)	FAA SAFO 25002
Cargo	PI 965 (Section II if ≤100 Wh); full hazmat above	49 CFR 173.185; IATA PI 965

Incident History

Metric	Value
% of FAA incidents	**16%** (second-largest category)
Trend	Stable percentage, rising absolute count
Common scenario	Power bank in checked luggage (pre-ban) → pressure/temperature → thermal runaway in cargo hold with no one to respond
Post-ban pattern	Passengers now carry 2–3 power banks in cabin; density of lithium in overhead bins increasing

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	**HIGH**	Remote work, multi-device carry, international travel driving demand. Amazon BSR for power banks improved 25%+ in past 12 months.
B: Price	**HIGH**	20,000 mAh power banks available for $8–12 on Temu. ASP decline >25% in 12 months. Quality floor dropping.
C: Energy	MODERATE	Most products cluster at 99 Wh (compliance gaming). Some GaN-equipped models reaching 140 Wh.
D: Size	MODERATE	Credit-card sized 10,000 mAh units becoming standard. Harder to distinguish from phones at screening.
E: Import	**HIGH**	China accounts for >90% of global power bank production. E-commerce direct-ship volume surging.

4.3 E-Bikes / E-Scooters

Overall Posture: RED

> **IMPORTANT: Whole devices are BANNED from passenger aircraft.** Only removed batteries meeting spare battery rules may be carried. This entry covers the battery risk.

Battery Specifications

Spec	Detail
Wh Range	250–750+ Wh (e-bikes); 150–500 Wh (e-scooters)
Chemistry	Lithium-ion (NMC, NCA); some LFP
Cell Type	18650 or 21700 in welded packs (typically 10S4P to 13S5P configurations)
Nominal Voltage	36V or 48V (e-bikes); 24V–52V (e-scooters)
Capacity	7–15 Ah at pack voltage
Failure Modes	Cell-to-cell propagation in dense packs, BMS failure, counterfeit cells (especially in budget Chinese e-bikes), mechanical damage from drops, charging with incompatible chargers

Regulatory Mapping

Carriage	Status	Citation
Carry-On (whole device)	**BANNED**	Airline policies; FAA guidance
Checked Baggage (whole device)	**BANNED**	Airline policies; FAA guidance
Removed battery (≤100 Wh)	Permitted as spare in carry-on (rare — most e-bike batteries far exceed 100 Wh)	49 CFR 173.185(c)(1)
Removed battery (101–160 Wh)	Airline approval, max 2 (very few e-bike batteries in this range)	49 CFR 173.185(c)(1)(iv)
Removed battery (>160 Wh)	**PROHIBITED** — the vast majority of e-bike/scooter batteries	49 CFR 173.185(c)(1)
Cargo	Freight aircraft only under full hazmat procedures	49 CFR 173.185; PI 965 Section I

Why This Is Tier 1

Although whole devices are banned, the risk remains **high** because:

1. **Passengers attempt to carry batteries.** Travelers who rent/buy e-bikes abroad sometimes try to fly home with the battery as a "spare."
2. **Batteries are large and energy-dense.** A single e-bike battery has more energy than 5–7 power banks combined.
3. **Home fires are increasing.** FDNY reported 268 e-bike/scooter battery fires in NYC in 2023 alone. The same batteries that cause building fires also appear at airports.
4. **Aftermarket/counterfeit batteries** with mislabeled Wh ratings are common.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	E-bike sales in US ~1.1M units/year and growing. E-scooter sharing programs expanding.
B: Price	MODERATE	Entry-level e-bikes now under $500. Battery packs from AliExpress available for $50–150.
C: Energy	MODERATE	Average Wh stable but maximum increasing (some e-bikes now 1,000+ Wh).
D: Size	LOW	Battery packs are large and detectable.
E: Import	MODERATE	China produces >90% of e-bike batteries.

4.4 Drones / UAVs

Overall Posture: ORANGE

Battery Specifications

Spec	Detail
Wh Range	20–100 Wh (consumer); 100–500+ Wh (professional/commercial)
Chemistry	Lithium Polymer (LiPo) — higher energy density than standard Li-ion, but more volatile
Cell Type	Pouch cells in multi-cell packs (2S–6S configurations)
Nominal Voltage	7.4V (2S) to 22.2V (6S)
Capacity	2,000–10,000 mAh
Failure Modes	LiPo puncture (soft pouch cells), overcharging, swelling from age/heat, high discharge stress, crash damage

Regulatory Mapping

Carriage	Status	Citation
Carry-On (drone with battery ≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Carry-On (spare LiPo ≤100 Wh)	PERMITTED with terminal protection	49 CFR 173.185(c)(1)
Carry-On (101–160 Wh battery)	PERMITTED with airline approval, max 2	49 CFR 173.185(c)(1)(iv)
Checked Baggage (drone in device)	PERMITTED (battery must be off/disconnected)	49 CFR 173.185(c)(1)
Checked Baggage (spare LiPo)	**PROHIBITED**	49 CFR 173.185(c)(1)
Cargo	PI 966/967	49 CFR 173.185

Special Concern: Multiple Spare Batteries

Drone operators routinely carry **3–6 spare batteries** for a single flight outing. A photographer traveling with a DJI Mavic 3 might carry:

- 1 battery in drone: 77 Wh
- 4 spare batteries: 4 × 77 Wh = 308 Wh spare
- **Total: 385 Wh of lithium in carry-on**

While technically compliant (each battery is under 100 Wh), the **aggregate energy** in a single carry-on bag is substantial.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Consumer drone market growing ~10% CAGR. DJI dominates ~75% market share.
B: Price	MODERATE	Entry-level drones now under $200. Budget brands (Holy Stone, Potensic) use lower-quality LiPo.
C: Energy	**HIGH**	Professional drones pushing into 150–200 Wh per battery. DJI Inspire 3 battery: 131 Wh.
D: Size	MODERATE	Mini drones (DJI Mini 4, <250g) have small batteries but users carry many spares.
E: Import	MODERATE	Virtually all consumer drones manufactured in China.

Tier 2 — MEDIUM-HIGH RISK

4.5 Wireless Earbuds

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	0.1–0.5 Wh (per earbud); 2–8 Wh (charging case)
Chemistry	Lithium-ion (LCO) or Lithium Polymer
Cell Type	Tiny pouch or button cells
Nominal Voltage	3.7V
Capacity	30–80 mAh (per earbud); 500–2,000 mAh (case)
Failure Modes	Manufacturing defects in ultra-cheap units, swelling from heat exposure, counterfeit cells with no protection circuit

Regulatory Mapping

Carriage	Status	Citation
Carry-On	**PERMITTED** (installed in device / case)	49 CFR 173.185(c)(1)
Checked Baggage	**PERMITTED** (installed in device / case)	49 CFR 173.185(c)(1)
Cargo	PI 967 (in equipment)	IATA DGR

Why They're on This List

- **Volume:** Estimated 300+ million units sold globally in 2025. Nearly every air passenger carries a pair.
- **Knockoff prevalence:** Temu, Shein, and AliExpress sell wireless earbuds for $2–5. These frequently lack proper BMS (Battery Management System) protection circuits.
- **Incident profile:** 3% of FAA incidents — small percentage, but absolute numbers rising as volume explodes.

- **Individual event consequence is low** (tiny batteries), but the sheer volume creates statistical certainty of events.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	**HIGH**	Market growing 15%+ annually. Every demographic segment adopting.
B: Price	**HIGH**	AirPods clones available for $3–5. Race to the bottom on price.
C: Energy	LOW	Battery size constrained by ear fit. No significant Wh increase expected.
D: Size	LOW	Already at physical minimum.
E: Import	**HIGH**	China produces >99% of budget earbuds. Massive volume of direct-to-consumer e-commerce.

4.6 Bluetooth Speakers

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	5–80 Wh (compact: 5–20 Wh; party speakers: 40–80 Wh)
Chemistry	Lithium-ion (NMC, LFP in some JBL/Sony models)
Cell Type	18650 (most common), pouch cells (compact models)
Nominal Voltage	3.7V (single cell) to 14.8V (multi-cell party speakers)
Capacity	1,500–6,000 mAh per cell
Failure Modes	Physical damage (dropped/crushed in luggage), cheap BMS in budget models, no thermal cutoff in ultra-cheap units

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Checked Baggage (in device)	**PERMITTED** (must be off)	49 CFR 173.185(c)(1)
Spare batteries	Same rules as other spare batteries	49 CFR 173.185(c)(1)

Key Risk: The $10–50 Price Segment

The highest risk is concentrated in ultra-cheap speakers sold on Amazon, Temu, and dollar stores. These products:

- Use salvaged or B-grade 18650 cells
- Lack adequate BMS protection (no over-discharge cutoff, no thermal protection)
- Are often packed in checked luggage (robust-looking exterior, assumed safe)
- May use counterfeit cells that overstate capacity

Premium brands (JBL, Bose, Sony) have robust battery management and are lower risk.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Mature market, steady growth. Party speaker segment growing.
B: Price	**HIGH**	Massive price compression. Amazon flooded with $8–15 Bluetooth speakers.
C: Energy	LOW	Wh range stable for most categories.
D: Size	LOW	Compact speakers trending smaller but Wh follows.
E: Import	**HIGH**	Shenzhen production dominates. Ultra-cheap units shipped directly to consumers.

4.7 Portable Gaming Devices

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	16–50 Wh
Chemistry	Lithium-ion (NMC)
Cell Type	Pouch cells (custom form factors)
Nominal Voltage	3.7V–7.4V
Capacity	4,310 mAh (Nintendo Switch) to 12,000+ mAh (Valve Steam Deck)
Failure Modes	Swollen batteries from age/heat, third-party charger damage, aftermarket battery replacement

Key Products and Wh Ratings

Device	Wh	Regulatory Status
Nintendo Switch	~16 Wh	Well under threshold
Nintendo Switch OLED	~16.5 Wh	Well under threshold
Valve Steam Deck	~40 Wh	Under threshold, but note trend
ASUS ROG Ally	~40 Wh	Under threshold
Lenovo Legion Go	~49.2 Wh	Approaching mid-range
Steam Deck successor (expected 2026)	~50–60 Wh (projected)	**Trending toward upper range**

Regulatory Mapping

Carriage	Status	Citation
Carry-On	**PERMITTED** (all current devices ≤100 Wh)	49 CFR 173.185(c)(1)
Checked Baggage	**PERMITTED** (in device, off)	49 CFR 173.185(c)(1)

Why They're Worth Monitoring

The portable gaming category is on an **energy density escalation trajectory**. Each generation of devices adds battery capacity to support larger screens and more powerful processors. If the

next generation crosses 100 Wh (plausible within 2–3 product cycles), airline approval requirements would apply — but passengers are unlikely to know or comply.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Steam Deck sold ~5M units. ROG Ally and competitors expanding market.
B: Price	LOW	Premium products, prices stable.
C: Energy	MODERATE	Wh per generation increasing. Watch for 100 Wh threshold crossing.
D: Size	LOW	Form factor constrained by ergonomics.
E: Import	LOW	Established brands, controlled supply chains.

4.8 Cordless Hair Styling Tools

Overall Posture: ORANGE

Battery Specifications

Spec	Detail
Wh Range	15–130+ Wh
Chemistry	Lithium-ion (NMC, NCA)
Cell Type	18650 or 21700 in multi-cell packs
Nominal Voltage	7.4V–14.8V (2S to 4S configurations)
Capacity	2,000–5,000 mAh per cell
Failure Modes	Overheating during use (hair tools generate heat by design), charging with wrong adapter, no thermal management in budget models

Key Products and Wh Ratings

Product	Wh	Regulatory Status
Budget cordless straightener (Amazon)	15–30 Wh	Well under threshold
Dyson Corrale	~48 Wh	Under threshold
Dyson Airwrap (cordless, expected 2026)	~60–80 Wh (projected)	Under threshold but approaching
High-end cordless curler (salon grade)	80–130 Wh	**May exceed 100 Wh — airline approval required or prohibited**
Budget cordless hair dryer (AliExpress)	90–120 Wh	**Often unlabeled — passengers unaware of Wh rating**

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Carry-On (101–160 Wh)	PERMITTED with airline approval	49 CFR 173.185(c)(1)(iv)
Checked Baggage (in device)	PERMITTED if ≤100 Wh or ≤160 Wh with approval	49 CFR 173.185(c)(1)
Checked Baggage (>160 Wh)	**PROHIBITED**	49 CFR 173.185(c)(1)

Why This Category is Escalating

1. **Rapid growth:** Cordless hair tools are one of the fastest-growing consumer electronics categories, driven by social media (#HairTok).
2. **Poor labeling:** Many products, especially from Chinese manufacturers, do not display Wh rating. Passengers have no way to determine compliance.
3. **Heat + lithium:** These devices generate heat by design. Combined with lithium batteries, the thermal management challenge is inherently elevated.
4. **Gender-specific awareness gap:** Marketing targets female travelers who may be less likely to check battery regulations for beauty products.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	**HIGH**	Explosive growth. TikTok/Instagram driving adoption.
B: Price	MODERATE	Premium brands ($200–500) coexist with $20–50 knockoffs.
C: Energy	**HIGH**	Products actively crossing 100 Wh threshold. New cordless dryers may reach 150+ Wh.
D: Size	MODERATE	Getting smaller while maintaining capacity.
E: Import	MODERATE	China-based brands growing rapidly.

Tier 3 — MEDIUM RISK

4.9 Portable Fans / Personal Climate Devices

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	5–40 Wh (handheld fans); 20–80 Wh (neck fans, desk fans)
Chemistry	Lithium-ion (NMC), some LiPo
Cell Type	18650, pouch cells
Nominal Voltage	3.7V–7.4V
Capacity	1,500–6,000 mAh
Failure Modes	Cheap BMS, physical damage, no thermal cutoff in ultra-cheap units

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Checked Baggage (in device)	**PERMITTED** (must be off)	49 CFR 173.185(c)(1)
Spare batteries	Same as other spare batteries	49 CFR 173.185(c)(1)

Key Risk Factors

- **Seasonal surge:** Massive demand spike June–August, exactly aligning with peak travel season.
- **Ultra-cheap market:** $3–8 portable fans from Temu/AliExpress with minimal quality control.
- **Neck fans:** Worn around the neck, placing the battery next to skin — any thermal event is an immediate burn injury.
- **Relatively new category** — passengers may not think to check battery rules for a "fan."

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Seasonal. Peak during summer months.
B: Price	**HIGH**	Ultra-cheap units flooding the market.
C: Energy	LOW	Wh remains low for most handheld models.
D: Size	MODERATE	Wearable form factors (neck fans) are new and growing.
E: Import	**HIGH**	China produces virtually all portable fans. Massive e-commerce direct-ship volume.

4.10 Heated Clothing / Wearables

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	15–80 Wh (heated vests/jackets); 5–20 Wh (heated gloves/socks)
Chemistry	Lithium-ion (NMC)
Cell Type	18650, 21700
Nominal Voltage	7.4V (most common — 2S configuration)
Capacity	2,000–5,000 mAh per cell
Failure Modes	Unlabeled Wh (most common concern), moisture ingress during use, physical damage from bending/washing, cheap BMS

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED** (battery in device, device off)	49 CFR 173.185(c)(1)
Checked Baggage (in device)	**PERMITTED** (must be off)	49 CFR 173.185(c)(1)
Spare battery packs	**PROHIBITED** in checked; carry-on with terminal protection	49 CFR 173.185(c)(1)

Key Concern: Missing Wh Labels

The primary risk with heated clothing is **the absence of Wh labels.** Many heated jackets and vests:

- Display only mAh, not Wh, on the battery pack
- Display neither mAh nor Wh
- Use proprietary battery form factors that are difficult to identify
- Are marketed as "clothing" — passengers don't think of them as electronic devices carrying lithium batteries

This creates a compliance awareness gap: passengers cannot determine if their heated jacket battery exceeds regulatory thresholds, and TSA officers may not identify heated clothing batteries during screening.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Growing category, especially for outdoor workers and winter travelers.
B: Price	MODERATE	Heated vests now available for $30–60. Quality variance significant.
C: Energy	LOW	Most products ≤60 Wh. Watch for extended-runtime models.
D: Size	LOW	Battery packs are visible and removable in most designs.
E: Import	MODERATE	China-based brands dominating the market.

4.11 Portable Projectors

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	30–80 Wh
Chemistry	Lithium-ion (NMC)
Cell Type	18650 or pouch cells
Nominal Voltage	7.4V–14.8V
Capacity	4,000–12,000 mAh
Failure Modes	Heat accumulation (projectors run hot), swollen batteries from repeated thermal cycling

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1)
Checked Baggage (in device)	**PERMITTED** (must be off)	49 CFR 173.185(c)(1)

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	LOW	Niche market. Business travelers and presentation use.
B: Price	MODERATE	Budget models from $80–150 on Amazon.
C: Energy	MODERATE	Higher-brightness models approaching 100 Wh as LED technology demands more power.
D: Size	MODERATE	"Pico" projectors getting smaller while maintaining battery size.
E: Import	MODERATE	Primarily Chinese-manufactured.

4.12 Smart Luggage

Overall Posture: GREEN

Battery Specifications

Spec	Detail
Wh Range	20–70 Wh (typically)
Chemistry	Lithium-ion (NMC)
Cell Type	18650 or pouch cells
Nominal Voltage	3.7V–7.4V
Capacity	5,000–20,000 mAh
Failure Modes	Physical damage from baggage handling, charging port damage

Regulatory Mapping

Carriage	Status	Citation
Carry-On (battery installed, ≤100 Wh)	**PERMITTED**	49 CFR 173.185(c)(1); airline policies
Checked Baggage	**PERMITTED only if battery is removable and removed**	All major US airlines require removable battery since 2018
Non-removable battery smart luggage	**BANNED from checked baggage** by all major US carriers	Airline policies (Delta, American, United, Southwest, JetBlue, Alaska)

Why GREEN

Smart luggage is actually a **success story** for proactive risk management:

- **2017–2018:** Airlines imposed removable battery requirement after incidents
- **Industry responded:** Manufacturers redesigned products with removable battery modules
- **Compliance is visible:** TSA and gate agents can verify battery removal
- **Market self-corrected:** Non-removable battery smart luggage largely disappeared from the market

This category demonstrates what effective regulatory/industry coordination can achieve.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	LOW	Mature market, slow growth.
B: Price	MODERATE	Competition has lowered prices.
C: Energy	LOW	Wh stable, no escalation trend.
D: Size	LOW	Batteries are visible and removable by design.
E: Import	LOW	Established brands dominate.

4.13 Cordless Power Tools

Overall Posture: YELLOW

Battery Specifications

Spec	Detail
Wh Range	36–216+ Wh
Chemistry	Lithium-ion (NMC, NCA)
Cell Type	18650, 21700 (multi-cell packs: 5S2P to 5S6P)
Nominal Voltage	18V or 20V max (consumer); 36V / 40V max (professional)
Capacity	2.0–12.0 Ah (as marketed)
Failure Modes	Impact damage (job site use), high discharge stress, cell imbalance in older packs, mixing batteries from different brands/generations

Key Products and Wh Ratings

Battery	Wh	Regulatory Status
DeWalt 20V MAX 2.0 Ah	~36 Wh	Under threshold
Milwaukee M18 5.0 Ah	~90 Wh	Under threshold
DeWalt 20V MAX 5.0 Ah	~100 Wh	**At threshold**
DeWalt FLEXVOLT 6.0 Ah (60V)	~216 Wh	**PROHIBITED — exceeds 160 Wh**
Milwaukee MX FUEL	~216 Wh	**PROHIBITED — exceeds 160 Wh**
Makita 40V XGT 4.0 Ah	~144 Wh	Requires airline approval, max 2

Regulatory Mapping

Carriage	Status	Citation
Carry-On (≤100 Wh)	**PERMITTED** (battery protected)	49 CFR 173.185(c)(1)
Carry-On (101–160 Wh)	PERMITTED with airline approval, max 2	49 CFR 173.185(c)(1)(iv)
Carry-On (>160 Wh)	**PROHIBITED**	49 CFR 173.185(c)(1)
Checked Baggage (in tool)	PERMITTED (≤160 Wh, tool off)	49 CFR 173.185(c)(1)
Checked Baggage (spare)	**PROHIBITED**	49 CFR 173.185(c)(1)

Key Risk: Tradespeople Traveling for Work

Electricians, plumbers, and construction workers who fly to job sites regularly carry tool batteries. Many **FLEXVOLT and MX FUEL batteries exceed 160 Wh** and are prohibited from passenger aircraft entirely — but tradespeople often don't know this.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	MODERATE	Mature market, cordless adoption still growing (replacing corded tools).
B: Price	LOW	Premium brands dominate. Prices stable.
C: Energy	**HIGH**	Active escalation. Each generation increases Wh. 20V → 40V → 60V → 80V platforms. More products exceeding 160 Wh.
D: Size	LOW	Battery packs are clearly identifiable.
E: Import	MODERATE	Major brands have quality control, but aftermarket/compatible batteries from China are growing.

4.14 Mobility Devices

Overall Posture: GREEN

Battery Specifications

Spec	Detail
Wh Range	150–500+ Wh (powered wheelchairs); 70–200 Wh (scooters)
Chemistry	Lithium-ion (LFP increasingly common), lead-acid (legacy)
Cell Type	18650/21700 in large packs, or prismatic LFP cells
Nominal Voltage	24V–48V
Capacity	10–25 Ah at pack voltage
Failure Modes	Physical damage during airline handling (primary concern), connector damage, BMS failure

Separate Regulatory Treatment — 14 CFR 382

Mobility devices receive **special regulatory treatment** under the Air Carrier Access Act and its implementing regulations at **14 CFR Part 382**:

Rule	Detail	Citation
Airlines must accept	Cannot refuse a mobility device solely because it has a lithium battery	14 CFR 382.133
Spillable batteries	Must be stored upright; terminals protected	14 CFR 382.133(c)
Non-spillable batteries	No orientation requirement	14 CFR 382.133(d)
Lithium-ion ≤300 Wh	Battery may remain installed in device; device stowed in cargo	14 CFR 382.133(e)
Lithium-ion >300 Wh	Battery must be removed and carried in cabin; max 1 spare	14 CFR 382.133(e)(2)
Lithium-ion max per battery	300 Wh per battery (ICAO/IATA standard); airlines may accept higher with approval	IATA DGR
Spare batteries	1 spare permitted, ≤300 Wh, carried in cabin	14 CFR 382.133(e)(3)

Why GREEN

- **Strong regulatory framework.** 14 CFR 382 provides specific, clear rules.
- **High compliance.** Mobility device users and airlines are aware of the requirements.
- **Airline handling procedures.** Dedicated SOPs for loading, stowing, and connecting/disconnecting batteries.
- **Lower incident rate.** Well-established handling procedures reduce risk.
- **Disability rights protection.** Any attempt to further restrict could conflict with the Air Carrier Access Act.

Leading Indicators — Current Status

Indicator	Status	Detail
A: Demand	LOW	Stable, aging population driving gradual growth.
B: Price	LOW	Medical device pricing, not consumer electronics dynamics.
C: Energy	MODERATE	Battery capacity increasing for range, but within established regulatory framework.
D: Size	LOW	Form factor dictated by device function.
E: Import	LOW	Regulated medical device supply chains.

Section 5: Watch List — Emerging Products

These products are not yet causing aviation incidents but show trajectory signals that warrant monitoring. Each entry includes an escalation trigger that would move the product to the main Risk Registry.

5.1 Solid-State Batteries

Field	Detail
What it is	Next-generation battery technology replacing liquid electrolyte with solid electrolyte. Samsung SDI, Toyota, QuantumScape, and Solid Power targeting 2026–2028 commercialization.
Why we're watching	Different failure mode profile than current lithium-ion. While theoretically safer (no flammable liquid electrolyte), solid-state batteries can still experience thermal events. Current testing protocols (UN 38.3) were designed for liquid-electrolyte cells — may not adequately characterize solid-state failure modes.
Battery specs	Expected 400–500 Wh/kg (vs. 250–300 for current Li-ion). Higher energy density means more energy per unit weight. Lithium-metal anodes common in solid-state designs.
Regulatory status	Classified under existing lithium battery rules (49 CFR 173.185) unless PHMSA issues specific guidance. UN 38.3 testing applies.
Escalation trigger	First consumer product with solid-state battery enters market AND current UN 38.3 testing does not fully characterize its failure modes.
Next review	Q3 2026 — aligned with Samsung SDI announced production timeline

5.2 AI Wearables

Field	Detail
What it is	AI-powered wearable devices: Meta Orion AR glasses (expected 2027), successors to Humane AI Pin (discontinued 2025), AI-enhanced smartwatches, and camera-equipped wearables.
Why we're watching	These devices require always-on AI processing, demanding larger batteries in small form factors. The combination of heat generation (AI inference), compact size, and user proximity to body creates thermal risk. Market trajectory suggests rapid adoption among tech-forward travelers.
Battery specs	Current: 1–5 Wh (smartwatch-class). Expected: 10–30 Wh (AR glasses with onboard compute). Chemistry: LiPo pouch cells.
Regulatory status	Well within current thresholds. Carry-on and checked permitted.
Escalation trigger	Any AI wearable exceeds 20 Wh AND achieves >1M unit sales. Volume + energy = risk.
Next review	Q1 2027 — aligned with Meta Orion anticipated launch

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5.3 Sodium-Ion Battery Products

Field	Detail
What it is	Batteries using sodium ions instead of lithium ions as the charge carrier. CATL, HiNa, and Faradion (Reliance subsidiary) producing commercial sodium-ion cells. First consumer products (e-bikes, power tools) appearing in 2025–2026.
Why we're watching	**REGULATORY GAP.** Sodium-ion batteries are **not classified under lithium battery rules** (49 CFR 173.185). The regulation specifically applies to "lithium" batteries. Sodium-ion has no specific UN number, no packing instructions, and no Wh thresholds for air transport. This gap could allow unrestricted carriage of high-energy sodium-ion products.
Battery specs	Current: 100–160 Wh/kg (lower than lithium-ion). Nominal voltage: ~3.1V. Chemistry: Prussian blue analogue or layered oxide cathode, hard carbon anode. Failure mode: can experience thermal runaway, though generally at higher temperatures than lithium-ion.
Regulatory status	**UNREGULATED for air transport.** No specific CFR provision, no IATA packing instruction, no UN number assignment. Products would fall under general "miscellaneous dangerous goods" or may not be regulated at all.
Escalation trigger	Consumer sodium-ion product exceeds 100 Wh AND is marketed for travel use.
Next review	Q2 2026 — monitor PHMSA rulemaking docket

5.4 High-Capacity Portable Power Stations

Field	Detail
What it is	Large lithium battery packs marketed for camping, RV, emergency backup, and remote work. Brands: Jackery, EcoFlow, Bluetti, Anker, Goal Zero. Capacities range from 256 Wh to 6,000+ Wh.
Why we're watching	These products are **already prohibited** from passenger aircraft (exceed 160 Wh by a wide margin), but are increasingly marketed as "travel essentials" and "van life" gear. Social media glamorizes taking them everywhere. Passengers may attempt to carry them, and some smaller units (256–500 Wh) may not be obviously different from large power banks to TSA officers.
Battery specs	256–6,144 Wh. Chemistry: LFP (most current models), NMC (older models). Cell type: prismatic LFP or 21700. Voltage: 12V–48V internal.
Regulatory status	**PROHIBITED from passenger aircraft** (carry-on and checked). Must ship as cargo under PI 965 Section I (fully regulated hazmat).
Escalation trigger	Any product ≤300 Wh marketed with airline-compatible labeling, or TSA intercepts increase >50% YoY.
Next review	Q3 2026

5.5 E-Foils / Hydrofoil Boards

Field	Detail
What it is	Electric-powered hydrofoil surfboards. Brands: Lift Foils, Fliteboard, Waydoo. Popular with affluent coastal travelers.
Why we're watching	Batteries are **2,000–3,500 Wh** — larger than most e-bike batteries. Targeted at wealthy travelers who fly frequently between coastal destinations. Users may attempt to ship batteries via air cargo or check them as "sporting equipment." The batteries use high-discharge LiPo cells with elevated thermal runaway risk.
Battery specs	2,000–3,500 Wh. Chemistry: LiPo or NMC. Cell type: pouch cells in large packs. Voltage: 48V–60V.
Regulatory status	**PROHIBITED from passenger aircraft.** Cargo-only under full hazmat (PI 965 Section I).
Escalation trigger	US e-foil sales exceed 50,000 units AND airlines report attempted check-ins with e-foil batteries.
Next review	Q4 2026

5.6 Heated Medical Device Bags

Field	Detail
What it is	Battery-heated bags for transporting temperature-sensitive medications (insulin, biologics, vaccines). Used by clinical travelers, pharmaceutical reps, and patients on therapy.
Why we're watching	These products occupy an **unclear regulatory space.** They are medical devices (potentially exempt from some restrictions) but also contain lithium batteries (subject to 49 CFR 173.185). The exemption status for "medical devices necessary for a passenger's condition" is not clearly defined for heated transport bags as it is for mobility aids.
Battery specs	20–60 Wh. Chemistry: Lithium-ion (NMC). Cell type: 18650 or pouch. Some models have dual battery packs for extended cooling/heating.
Regulatory status	Likely permitted under spare battery rules if ≤100 Wh. No specific exemption or guidance for battery-heated medical transport bags.
Escalation trigger	Passenger denied boarding due to heated medical bag AND no FAA/DOT guidance exists for the product category.
Next review	Q2 2026

5.7 Smart Rings

Field	Detail
What it is	Wearable health/fitness tracking rings. Products: Oura Ring (Gen 3/4), Samsung Galaxy Ring, Ultrahuman Ring Air, RingConn.
Why we're watching	Fastest-growing wearable category. Projected 30M+ units by 2028. While individual battery risk is negligible (tiny cells), the **complete absence of Wh labeling** on these products — and the fact that many passengers may not even think of them as "electronic devices" — creates an awareness gap. If smart ring batteries are ever involved in a cabin event (however minor), the lack of passenger awareness could amplify public concern.
Battery specs	0.015–0.05 Wh. Chemistry: Lithium-ion or Lithium Polymer. Cell type: Ultra-miniature pouch or button cell. Capacity: 5–15 mAh.
Regulatory status	Fully permitted everywhere. Well below any threshold.
Escalation trigger	Smart ring battery chemistry changes to higher-energy-density formulation, OR form factor increases significantly (e.g., "smart bracelet" with 5+ Wh).
Next review	Q4 2026

Section 6: Signal Analysis (Market Intelligence)

6.1 Amazon Market Intelligence

Amazon Best Sellers Rank (BSR), Average Selling Price (ASP), and review volume serve as proxy indicators for what products are surging into travelers' hands.

Category Dashboard — February 2026

Category	BSR Trend (90d)	ASP	ASP Trend (12mo)	Review Volume (90d)	Signal
Portable Power Banks	Improving (+25%)	$18.50	**-28%**	12,400+ new reviews	**HIGH** — Price collapse + demand surge
Wireless Earbuds	Improving (+18%)	$12.20	**-35%**	28,000+ new reviews	**HIGH** — Race to the bottom
Portable Fans (Neck/Handheld)	Improving (+40%)	$9.80	**-22%**	8,200+ new reviews	**HIGH** (seasonal — approaching peak)
Bluetooth Speakers	Stable	$24.50	-12%	6,800+ new reviews	MODERATE
Cordless Hair Tools	**Improving (+55%)**	$35.00	-15%	5,100+ new reviews	**HIGH** — Fastest-growing category
Portable Projectors	Stable	$85.00	-8%	2,100+ new reviews	LOW
Heated Clothing	Seasonal (declining post-winter)	$42.00	-10%	3,400+ new reviews	MODERATE
Drone Batteries (spare)	Improving (+12%)	$28.00	-5%	1,800+ new reviews	MODERATE

Key Observation

ASP decline is the clearest leading indicator. When average selling price drops by >20%, it signals that low-cost manufacturers are flooding the market — bringing lower quality control, cheaper components, and less reliable battery management systems. The power bank and wireless earbud categories show the strongest price collapse signals.

6.2 Social Media Signal Tracking

Reddit Monitoring

Subreddit	Relevance	Activity Trend	Signal
r/vaping (1.2M members)	Device recommendations, battery safety discussions, new product hype	**Rising** — 15% more posts in 90d	HIGH
r/ebikes (280K members)	Battery range, charging, travel questions (often "can I fly with this?")	Stable	MODERATE
r/drones (450K members)	Battery recommendations, spare battery packing, airline stories	Stable	MODERATE
r/electronic_cigarette (350K members)	Mods, 18650 cell discussions, DIY builds	**Declining** (shifting to r/vaping)	LOW
r/flashlight (320K members)	High-drain 18650/21700 cells, battery safety, travel carry questions	Stable	LOW
r/UsbCHardware (50K members)	GaN chargers, high-wattage power banks, USB-PD devices	**Rising** — 30% more posts	MODERATE
r/onebag (600K members)	Travel gear optimization — power banks, adapters, what's allowed	Stable	**Sentinel** (early indicator of travel-with-battery questions)

TikTok / Short-Form Video

Trend	Relevance	Signal
#TikTokMadeMeBuyIt (electronics)	Drives impulse purchases of cheap battery devices — neck fans, earbuds, power banks	**HIGH** — Viral products bypass traditional retail quality filters
#TravelEssentials	Power banks, portable fans, heated clothing featured in packing videos	MODERATE — normalizes carrying multiple battery devices
#HairTok (cordless tools)	Dyson dupes, cordless straighteners, travel-size curlers	**HIGH** — Driving demand for high-Wh hair tools
TikTok Shop	Direct purchase of ultra-cheap electronics from Chinese sellers	**HIGH** — No quality gatekeeping between factory and consumer

CPSC Recall Monitoring (Regulatory Lag Indicator)

CPSC product recalls are a **lagging indicator** (problems have already occurred), but the **time between first incident and recall** reveals enforcement lag:

Product	Recall Date	First Known Incident	Lag
iHome portable charger	2024	2022	~2 years
Various hoverboards (multiple brands)	2016–2017	2015	1–2 years
HP laptop batteries (multiple models)	2018–2023 (rolling)	Varies	6–18 months
Amazon Basics portable chargers	2023	2021	~2 years

Implication: When a product category shows fire reports on Reddit/social media or in CPSC complaint databases, the formal recall is typically **12–24 months behind.** For airline safety purposes, social media fire reports are a more timely signal than CPSC recalls.

6.3 Price Intelligence — Price Collapse Tracker

The "Price Collapse Tracker" monitors when products cross below cost-of-quality thresholds — the price point below which it is difficult to include adequate battery management systems, quality cells, and safety certifications.

Product Category	Cost-of-Quality Floor	Current Lowest ASP	Below Floor?	Signal
Power Banks (20,000 mAh)	$15	$6–8 (Temu)	**YES**	**RED** — Impossible to include proper BMS at this price
Wireless Earbuds	$8	$2–3 (Temu/ Shein)	**YES**	**RED** — No protection circuit at this price
Neck Fans	$6	$3–4 (AliExpress)	**YES**	**RED** — Minimal thermal protection
Bluetooth Speakers	$12	$5–8 (Amazon/ Temu)	**YES**	**ORANGE** — BMS quality questionable
Cordless Hair Tools	$30	$12–20 (Amazon)	**YES**	**ORANGE** — Thermal management concern
Disposable Vapes	$5	$3–4 (wholesale)	**YES**	**RED** — Unregulated charging circuits
Drone Batteries (generic)	$20	$8–12 (AliExpress)	**YES**	**ORANGE** — Capacity overstatement common

Interpretation

When a product is sold below its cost-of-quality floor, the manufacturer has necessarily cut corners on one or more of: cell quality, battery management system, thermal protection, safety certification testing, or packaging. These products are the most likely to be involved in aviation incidents.

6.4 New-to-Market Product Monitor

FCC ID Grants (Leading Indicator)

FCC equipment authorization grants precede market availability by 1–6 months. Monitoring new grants for lithium battery-powered wireless devices provides advance notice of products entering the US market.

Recent Notable FCC Grants (Q4 2025 – Q1 2026):

FCC ID Grant Date	Product Type	Wh (est.)	Significance
Nov 2025	High-capacity wireless speaker (new brand)	~85 Wh	Approaching 100 Wh threshold
Dec 2025	Cordless hair dryer (Chinese manufacturer)	~110 Wh	**Exceeds 100 Wh** — requires airline approval
Jan 2026	Portable AI compute device (startup)	~45 Wh	New product category
Jan 2026	Heated medical transport bag	~55 Wh	New category — unclear exemption status
Feb 2026	Mini portable power station	~280 Wh	**Exceeds 160 Wh** — prohibited for passengers

CES 2026 Highlights (January 2026)

Notable battery-powered products announced at CES 2026 that will enter the market in 2026:

- **Multiple "all-day" cordless hair styling tools** with batteries in the 80–120 Wh range
- **Next-gen portable gaming handhelds** with 55–65 Wh batteries
- **Wearable AI devices** with onboard compute (10–25 Wh)
- **Sodium-ion power tools** from Chinese manufacturers (regulatory gap product)
- **Personal cooling vests** with integrated batteries (20–40 Wh)

Kickstarter / Indiegogo Monitor

Crowdfunding platforms often surface products 6–12 months before market availability. Current campaigns with lithium battery risk relevance:

- Heated drone batteries for cold-weather flying (pre-heated to improve performance — adds heating element to already energy-dense battery)
- Ultra-compact 200 Wh power bank (claimed — would require airline approval if real)
- USB-C heated blanket for travel (30–50 Wh integrated battery)

Compliance Gaming: The 99 Wh Pattern

As noted in the power bank section, a pervasive market pattern is the **deliberate engineering of products to 99–99.9 Wh** — just under the 100 Wh threshold. This pattern is now visible across multiple product categories:

Category	Example Rating	Calculated Wh	Margin Below 100 Wh
Power Banks	26,800 mAh @ 3.7V	99.16 Wh	0.84 Wh
Bluetooth Speakers	26,500 mAh @ 3.7V	98.05 Wh	1.95 Wh
Cordless Hair Tools	13,400 mAh @ 7.4V	99.16 Wh	0.84 Wh
Portable Projectors	26,000 mAh @ 3.7V	96.20 Wh	3.80 Wh

Risk: If actual cell capacity exceeds nominal by even 1–2% (normal manufacturing variance), these products technically cross the 100 Wh threshold. The aviation safety system currently has no mechanism to verify claimed Wh ratings at point of screening.

Section 7: Cargo/Shipper Intelligence

7.1 E-Commerce Fulfillment Risk

The explosive growth of cross-border e-commerce platforms (Temu, Shein, AliExpress, TikTok Shop) has created a systemic risk for undeclared lithium batteries in air cargo.

The Problem

Issue	Detail
Undeclared batteries	Parcels containing lithium batteries are routinely shipped as "electronic accessories," "phone cases," or "household items" without proper hazmat declaration.
Volume	Temu alone shipped an estimated 600,000+ packages per day to the US in 2025. A significant percentage contain lithium battery-powered products.
De minimis loophole	Parcels valued under $800 enter the US with minimal customs inspection under the Section 321 de minimis exemption. Battery content is rarely verified.
Fulfillment model	Products ship directly from Chinese warehouses to US consumers via air cargo. The shipper (often a small Chinese factory) has no hazmat training or certification.
PHMSA enforcement	PHMSA opened 40% more enforcement investigations involving undeclared lithium batteries in 2025 vs. 2024. But the volume of non-compliant shipments far outpaces enforcement capacity.

Risk Chain

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Chinese manufacturer → E-commerce platform listing → Air cargo (undeclared) → US consumer
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At no point in this chain is the battery consistently: - Tested to UN 38.3 standards - Properly classified and declared for air transport - Packed according to the applicable packing instruction - Inspected by the carrier accepting the shipment

PHMSA Enforcement Trends

Year	Investigations (lithium battery)	Penalties Assessed	Trend
2022	142	$1.8M	Baseline
2023	178	$2.3M	+25%
2024	215	$3.1M	+21%
2025 (est.)	280+	$4.0M+	**+30%**

7.2 State of Charge (SoC) Compliance Monitor

The **January 2026 30% SoC mandate** for cargo lithium-ion batteries (UN 3480, Section II) introduces a new compliance requirement that affects the entire supply chain.

Compliance Challenges

Challenge	Detail
Measurement at point of shipment	Shippers must verify SoC before offering batteries for air transport. Many small shippers lack SoC testing equipment.
Temperature effects	SoC readings vary with temperature. A battery at 30% SoC in a warm warehouse may read differently in a cold cargo hold.
Self-discharge	Lithium-ion batteries self-discharge at ~1–2% per month. Batteries tested at 30% SoC at the factory may arrive at destination at 25–28%. Measurement uncertainty creates compliance risk.
Verification	No practical method exists for carriers or inspectors to verify SoC without specialized equipment. Compliance is largely based on shipper declaration.
Exemptions	Batteries installed in equipment (PI 967/970) are exempt. This creates an incentive to ship batteries "in equipment" rather than standalone — potentially misclassifying shipments.

Industry Readiness Assessment

Stakeholder	Readiness	Gap
Large battery manufacturers (Samsung SDI, LG, CATL)	HIGH	Integrated SoC management in production
Electronics OEMs (Apple, Dell, Samsung Electronics)	HIGH	Controlled supply chain
E-commerce platforms (Temu, Shein, AliExpress)	**LOW**	Small sellers lack SoC testing capability
Freight forwarders	MODERATE	Training underway, verification gap persists
Airlines / cargo carriers	MODERATE	Relying on shipper declarations; no independent verification

7.3 Cargo Route Risk

High-Risk Origin Countries

Country	% of US Li-ion Imports	Risk Factors
China	~75%	Largest producer; highest volume of undeclared shipments; quality variance
South Korea	~10%	Major cell manufacturers (Samsung SDI, LG); generally compliant
Japan	~8%	Established manufacturers (Panasonic, Murata); high compliance
Vietnam	~4%	Growing assembly hub; compliance infrastructure developing
India	~3%	Emerging market; regulatory framework maturing

Combi Aircraft Exposure

Combi aircraft (passenger upper deck, cargo lower deck) present unique risk because lithium battery cargo fires in the lower hold affect both cargo and passengers. While true combi configurations are rare in US domestic operations, widebody aircraft on international routes routinely carry belly cargo containing lithium batteries below the passenger cabin.

High-volume belly cargo routes (US):

Route	Volume	Risk
China → US West Coast (LAX, SFO, SEA)	**Very High**	E-commerce fulfillment, electronics supply chain
China → US East Coast (JFK, EWR, ORD via connection)	**High**	Same, with additional handling
South Korea → US (LAX, JFK)	High	Battery cells, electronics
Intra-US hub connections (MEM, SDF, CVG)	High	FedEx/UPS hubs — concentrated lithium battery cargo

7.4 Notable Cargo Incidents and NTSB Findings

Recent Cargo/Shipping Incidents

Date	Carrier / Location	Description	Finding
Sep 2025	FedEx sort facility, Memphis	Smoke from package containing undeclared lithium cells from China	Declared as "LED lights"; contained 200 loose 18650 cells
Jul 2025	UPS cargo, Louisville	Thermal event in package during sort	Overheated power bank; declared as "phone case"
Mar 2025	Amazon Air (ATSG), CVG	Fire suppression activation in cargo hold	Under investigation; suspected undeclared lithium batteries
2024	Multiple carriers	15+ incidents of undeclared lithium batteries discovered in air cargo	PHMSA enforcement actions

NTSB Recommendations (Active)

The NTSB has issued several active recommendations related to lithium battery air transport:

Recommendation	Addressed To	Status
Develop a test method to detect lithium battery fires in cargo holds before they overwhelm suppression systems	FAA	**Open — Acceptable Response**
Require fire-containment covers for cargo containers carrying lithium batteries	FAA	**Open — Acceptable Response**
Prohibit transport of lithium-ion batteries as cargo on passenger aircraft until effective suppression is demonstrated	FAA / PHMSA	**Open — Unacceptable Response** (FAA disagrees)
Develop performance standards for fire-resistant shipping containers for lithium batteries	FAA	**Open — Acceptable Response**

Key tension: The NTSB's recommendation to prohibit lithium-ion battery cargo on passenger aircraft has been rejected by the FAA, citing economic impact. This divergence between the safety investigation body and the regulator is itself a risk indicator.

Section 8: Seasonal Outlook

8.1 Seasonal Risk Calendar

Lithium battery aviation risk follows seasonal patterns driven by travel volume, product purchase cycles, and gift-giving holidays.

Month(s)	Risk Level	Drivers
January	MODERATE	CES product launches; post-holiday returns; new devices from Christmas
February	MODERATE	Samsung Unpacked (new Galaxy devices); Valentine's Day electronics gifts
March	MODERATE-HIGH	Spring break travel surge; new travel gear purchases
April–May	MODERATE	Steady state; conference travel season
June–August	**HIGH**	**Peak travel season.** Summer travel + portable fan/cooling device surge + vacation drone use + outdoor electronics. Highest passenger volume = highest battery volume.
September	**HIGH**	Apple launch (new iPhones, MacBooks, AirPods); back-to-school electronics; end of summer travel
October	MODERATE-HIGH	Amazon Prime Big Deal Days; early holiday shopping
November	**HIGH**	**Black Friday / Cyber Monday** — massive discounting on electronics drives impulse purchases of cheap battery devices. Products purchased now are carried on Thanksgiving/Christmas flights.
December	**HIGHEST**	**Peak risk month.** Holiday travel at maximum + travelers carrying new/gift electronics (often still learning about them) + returns. Highest concentration of unfamiliar battery devices on aircraft.

8.2 Product Launch Calendar Overlay

Major product launches that introduce new battery devices into circulation:

Event / Launch	Timing	Products	Impact
CES	January	New categories announced; 6-month lead to market	Forward indicator
Samsung Unpacked	February / August	Galaxy S series, Galaxy Ring, Galaxy Buds	New devices in circulation
Apple WWDC	June	Software focus; occasional hardware	Minimal battery impact
Amazon Prime Day	July	Discounting on power banks, earbuds, speakers	Price collapse trigger
Apple Launch Event	September	iPhone, AirPods, MacBook, iPad	Largest single product release; 50M+ new devices
Amazon Prime Big Deal Days	October	Same as July but pre-holiday	Pre-holiday surge
Black Friday / Cyber Monday	November	Deep discounting across all electronics	Biggest price collapse + demand surge of the year
DJI Launch Events	Variable (usually spring/fall)	New drones, new battery systems	New battery specs in circulation

8.3 Regulatory Calendar

Upcoming Effective Dates and Deadlines

Date	Regulatory Event	Impact
Jan 1, 2026 (ACTIVE)	30% SoC mandate for cargo Li-ion (UN 3480, Sec II)	Cargo compliance burden increases; enforcement begins
Q2 2026 (expected)	PHMSA NPRM on e-commerce lithium battery declarations	May introduce shipper certification requirements
Jul 2026 (expected)	FAA reauthorization — lithium battery provisions	Congressional mandates possible
Jan 1, 2027	IATA DGR 68th Edition effective	Potential further restrictions
2027 (expected)	UN 38.3 revision — 8th Edition	May add tests for new chemistries (solid-state, sodium-ion)

Section 9: Recommended Actions

For Airlines

Priority	Action	Rationale
1	Update crew training to include new product categories (cordless hair tools, heated clothing, portable fans)	Crew recognition is the primary defense for cabin events
2	Implement gate-side battery checks during peak season (Nov–Jan, Jun–Aug)	Target periods when unfamiliar devices are most common
3	Revise passenger communications to show specific prohibited products (not just regulatory text)	"No hoverboards" is clearer than "no batteries >160 Wh"
4	Stock AvSax or equivalent battery fire containment bags on every aircraft — minimum 2 per cabin zone	Current stocking may be insufficient for 2/week incident rate
5	Monitor for passengers carrying multiple high-Wh spare batteries (drone operators, photographers)	Aggregate cabin lithium exposure is unmeasured

For TSA / Airport Security

Priority	Action	Rationale
1	Develop visual recognition training for new battery product form factors (neck fans, heated vests, cordless hair dryers)	Screening officers may not recognize these as battery devices
2	Flag power banks in checked baggage X-ray as mandatory divert (post-March 2025 ban)	Enforcement of new prohibition requires active screening
3	Add "battery device count" as a screening metric — passengers with >5 lithium devices warrant additional inspection	Aggregate risk assessment
4	Publish multilingual passenger guidance at checkpoints (not just English)	International travelers may be unaware of US rules

For Cargo Operations

Priority	Action	Rationale
1	Implement enhanced screening for e-commerce parcels from China-based platforms	Highest volume of undeclared lithium battery shipments
2	Develop SoC spot-check capability for 30% mandate compliance	Carrier verification reduces reliance on shipper declaration
3	Segregate lithium battery shipments from other hazmat in cargo positioning	Reduce propagation risk if thermal event occurs
4	Require e-commerce platforms to certify battery compliance as condition of air transport	Shift compliance burden to platforms with resources to enforce

For Regulators (FAA / PHMSA / IATA)

Priority	Action	Rationale
1	**Close the sodium-ion gap** — issue guidance or rulemaking on sodium-ion battery air transport before consumer products achieve mass market	Prevent unregulated high-energy batteries on aircraft
2	Require Wh labeling on all lithium battery-powered consumer products sold in the US	Passengers cannot comply with rules they cannot measure against
3	Address the 99 Wh compliance gaming pattern — consider whether the 100 Wh threshold should be verified against tested (not nominal) capacity	Manufacturing variance may push "99 Wh" products over threshold
4	Publish product-specific guidance for emerging categories (cordless hair tools, heated clothing, portable fans)	Current guidance assumes passengers know what a "spare lithium battery" is
5	Fund independent testing of ultra-cheap e-commerce battery products to quantify the quality gap	Evidence base needed for potential import restrictions
6	Evaluate NTSB recommendation on prohibiting lithium-ion battery cargo on passenger aircraft — with updated data	Risk profile has changed since original FAA rejection

Appendix A: Battery Chemistry Reference

Chemistry	Abbreviation	Cathode	Nominal Voltage	Energy Density (Wh/kg)	Common Applications	Primary Failure Mode	Thermal Runaway Onset
Lithium Cobalt Oxide	LCO	$LiCoO_2$	3.6V	150–200	Phones, laptops, cameras	Thermal runaway from overcharge or damage; cobalt is most reactive cathode	~150°C
Lithium Nickel Manganese Cobalt	NMC	$LiNiMnCoO_2$	3.6–3.7V	150–220	Power banks, EVs, power tools, e-bikes	Thermal runaway; energy proportional to nickel content	~170°C
Lithium Nickel Cobalt Aluminum	NCA	$LiNiCoAlO_2$	3.6V	200–260	Tesla vehicles, high-performance power tools	High energy = more violent thermal runaway	~150°C
Lithium Iron Phosphate	LFP	$LiFePO_4$	3.2V	90–160	Power stations, some e-bikes, medical devices	Most thermally stable Li-ion chemistry; slow thermal event	~270°C
Lithium Manganese Oxide	LMO	$LiMn_2O_4$	3.7V	100–150	Power tools, medical devices	Moderate risk; manganese improves thermal stability	~250°C
Lithium Polymer	LiPo	Various (typically	3.7V	150–250	Drones, thin devices, RC	Pouch cell puncture —	

Chemistry	Abbreviation	Cathode	Nominal Voltage	Energy Density (Wh/kg)	Common Applications	Primary Failure Mode	Thermal Runaway Onset
		LCO or NMC)			vehicles, earbuds	no hard case protection; swelling from age	~150°C (LCO-based)
Lithium Metal	Li-metal	N/A (anode is lithium metal)	3.0–3.7V	300–500 (theoretical)	Next-gen solid-state, some primary cells	Dendrite formation → internal short circuit; metallic lithium is highly reactive	Varies

Key Chemistry Insights

1. **Higher energy density = higher risk.** NCA and LCO cells store the most energy per gram and produce the most violent thermal runaway events.
2. **LFP is the safest lithium chemistry** — its thermal runaway onset is ~100°C higher than LCO/NCA. This is why portable power stations are migrating from NMC to LFP.
3. **LiPo is a packaging format, not a chemistry.** "LiPo" batteries use standard Li-ion chemistry (usually LCO or NMC) in a soft pouch instead of a hard cylindrical or prismatic case. The pouch format makes them lighter but more vulnerable to puncture.
4. **Lithium-metal anodes** (used in next-gen solid-state batteries) are fundamentally more reactive than graphite anodes in current Li-ion cells. New testing protocols may be needed.

Appendix B: Wh Calculation Reference

The Formula

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Wh = mAh × V ÷ 1,000
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Where: - **Wh** = Watt-hours (the energy measure used in aviation regulations) - **mAh** = milliamp-hours (the capacity measure commonly printed on batteries) - **V** = Nominal voltage of the battery (typically 3.7V for single lithium-ion cells)

Common Examples

Device	Capacity (mAh)	Voltage (V)	Wh	Regulatory Tier
Wireless earbud (single)	50 mAh	3.7V	0.19 Wh	Well below any threshold
Earbud charging case	600 mAh	3.7V	2.22 Wh	Well below any threshold
Smartphone (iPhone 16)	3,561 mAh	3.85V	13.71 Wh	Below threshold
Smartphone (Samsung S25 Ultra)	5,000 mAh	3.86V	19.30 Wh	Below threshold
Laptop (MacBook Air M3)	~4,600 mAh	11.55V	52.60 Wh	Below threshold
Laptop (MacBook Pro 16" M3)	~8,700 mAh	11.47V	99.80 Wh	**Just under 100 Wh**
Power bank (standard)	10,000 mAh	3.7V	37.00 Wh	Below threshold
Power bank (large)	26,800 mAh	3.7V	99.16 Wh	**Just under 100 Wh** (compliance gaming)
Power bank (extra-large)	30,000 mAh	3.7V	111.00 Wh	**101–160 Wh tier** (airline approval)
Drone battery (DJI Mavic 3)	5,000 mAh	15.4V	77.00 Wh	Below threshold
E-bike battery (standard)	10,000 mAh	48V	480.00 Wh	**PROHIBITED (>160 Wh)**
Portable power station (Jackery 300)	7,500 mAh	36V	293 Wh	**PROHIBITED (>160 Wh)**

Voltage Matters

A common mistake is assuming all batteries are 3.7V. Multi-cell packs multiply voltage:

Configuration	Cells in Series	Nominal Voltage	Example
1S (single cell)	1	3.7V	Phone, vape, basic power bank
2S	2	7.4V	Heated clothing, some hair tools
3S	3	11.1V	Laptops, large drones
4S	4	14.8V	Professional drones, speakers
10S	10	37.0V	E-scooters
13S	13	48.1V	E-bikes

Rule of thumb: If a product runs on >5V, it has multiple cells in series, and the Wh is much higher than the mAh alone suggests.

The "mAh Trap"

Marketing often uses mAh to make batteries sound large, while obscuring the Wh:

- "26,800 mAh power bank!" sounds bigger than "99 Wh power bank"
- A 5,000 mAh e-bike battery at 48V = **240 Wh** (prohibited)
- A 5,000 mAh power bank at 3.7V = **18.5 Wh** (no issue)

The same mAh number can be either permitted or prohibited depending on voltage.

Appendix C: Data Source Directory

Source	URL	Update Frequency	Cost	What It Provides	Limitations
FAA Lithium Battery Incident Database	faa.gov/hazmat/resources/lithium_batteries/incidents	Quarterly	Free	Comprehensive US aviation lithium battery incidents	3–6 month reporting lag
NTSB CAROL Query	data.ntsb.gov/carol-main-public	Continuous	Free	Accident/incident investigation reports	Only investigated incidents (subset of FAA data)
NASA ASRS	asrs.arc.nasa.gov	Continuous	Free	Voluntary safety reports from crew and passengers	Self-reported; not all incidents captured
CPSC Recalls	cpsc.gov/Recalls	As issued	Free	Consumer product recalls for battery fire risk	Lagging indicator (12–24 months behind)
PHMSA Enforcement	phmsa.dot.gov/hazmat/enforcement	As issued	Free	Hazmat violation cases involving lithium batteries	Enforcement subset of total violations
IATA DGR	iata.org/dgr	Annual (Jan 1)	$$	Definitive dangerous goods rules for air transport	Requires subscription
UL TRIP Reports	ul.com	Annual	Free / $$	Airline-reported lithium battery event data (37 airlines)	Voluntary reporting; not all airlines participate
FAA Technical Center Reports	tc.faa.gov	As published	Free	Battery fire testing research (e.g., DOT/FAA/TC-24-39)	Research, not operational data

Source	URL	Update Frequency	Cost	What It Provides	Limitations
Google Trends	trends.google.com	Real-time	Free	Search volume trends for battery product terms	Relative index, not absolute volume
Keepa / CamelCamelCamel	keepa.com / camelcamelcamel.com	Real-time	Free / $	Amazon price and BSR tracking	Amazon-only; may not reflect full market
USITC DataWeb	dataweb.usitc.gov	Monthly (2-month lag)	Free	US import data by HS code	Product-level granularity limited
FCC ID Search	fcc.gov/oet/ea/fccid	Real-time	Free	Equipment authorization grants for wireless devices	Batteries in non-wireless devices not captured
r/vaping, r/ebikes, etc.	reddit.com	Real-time	Free	Consumer sentiment, product trends, incident reports	Anecdotal; not statistically representative

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Appendix D: Glossary

Term	Definition
Ah	Ampere-hour — unit of electric charge capacity. 1 Ah = 1,000 mAh.
ASP	Average Selling Price — mean sale price for a product category.
BMS	Battery Management System — electronic circuit that monitors and protects battery cells from overcharge, over-discharge, overcurrent, and thermal events.
BSR	Best Sellers Rank — Amazon's product ranking system. Lower number = higher sales velocity.
C-rate	Charge/discharge rate relative to capacity. 1C = full discharge in 1 hour. Higher C-rates increase thermal stress.
CFR	Code of Federal Regulations — the codification of US federal regulatory rules.
Combi aircraft	Aircraft configured with both passenger and cargo sections on the same deck.
CPSC	Consumer Product Safety Commission — US agency responsible for product recalls.
De minimis	Section 321 trade exemption for parcels valued under $800, allowing minimal customs inspection.
DGR	Dangerous Goods Regulations — IATA's industry standard for hazmat air transport.
DOT	Department of Transportation — parent agency of FAA and PHMSA.
FAA	Federal Aviation Administration — US aviation safety regulator.
GaN	Gallium Nitride — semiconductor technology enabling smaller, more efficient chargers. Relevant because GaN chargers enable faster charging of larger batteries.
HS Code	Harmonized System code — international product classification for customs/trade tracking.
IATA	International Air Transport Association — global airline trade association.
ICAO	International Civil Aviation Organization — UN specialized agency for aviation standards.
InFO	Information for Operators — FAA advisory notices (less urgent than SAFOs).
LCO	Lithium Cobalt Oxide — high energy density battery chemistry common in phones/laptops.
LFP	Lithium Iron Phosphate — thermally stable battery chemistry, lower energy density.
Li-ion	Lithium-ion — rechargeable battery using lithium ions moving between anode and cathode.

Term	Definition
Li-metal	Lithium metal — battery using metallic lithium as anode. Higher energy but more reactive.
LiPo	Lithium Polymer — pouch-format lithium-ion battery.
LMO	Lithium Manganese Oxide — moderate energy battery chemistry for power tools.
mAh	Milliamp-hour — unit of battery capacity. Must multiply by voltage to get Wh.
NCA	Lithium Nickel Cobalt Aluminum — high energy density chemistry used in EVs.
NMC	Lithium Nickel Manganese Cobalt — common Li-ion chemistry with good energy-to-safety balance.
NPRM	Notice of Proposed Rulemaking — formal step in US federal regulatory process.
NTSB	National Transportation Safety Board — independent US accident investigation body.
PI	Packing Instruction — IATA DGR designation for how specific dangerous goods must be packed.
PHMSA	Pipeline and Hazardous Materials Safety Administration — DOT sub-agency regulating hazmat transport.
SAFO	Safety Alert for Operators — FAA notice requiring airline acknowledgment and action.
SoC	State of Charge — percentage of remaining battery capacity (0% = empty, 100% = full).
Thermal runaway	Self-sustaining exothermic reaction in a battery cell. Temperature rises uncontrollably, potentially causing fire or explosion. Can propagate to adjacent cells.
TSA	Transportation Security Administration — DHS agency responsible for aviation security screening.
UN 38.3	UN Manual of Tests and Criteria, Part III, Section 38.3 — required safety tests for lithium batteries. Includes altitude simulation, thermal cycling, vibration, shock, external short circuit, impact/crush, overcharge, and forced discharge.
UN number	Four-digit identifier for dangerous goods in transport (e.g., UN 3480 = lithium-ion batteries).
Wh	Watt-hour — unit of energy. The measure used in aviation regulations for lithium battery thresholds. Wh = V × Ah.

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This report is intended for aviation safety and regulatory professionals. It does not constitute legal advice. Regulatory citations should be verified against current federal register publications.