European Union Aviation Safety Agency

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RESEARCH PROJECT [EASA.2022.HVP.22]

[STAGE 1: REVIEW STATE OF THE ART SOLUTIONS]

Detection of lithium batteries using security screening equipment

An Agency of the European Union

Disclaimer

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SUMMARY

Problem area

Lithium batteries are becoming more and more prevalent in portable electronics devices. Their diverse form-factors and favourable energy storage characteristics make them a prime choice of batteries in many applications. Yet the high density of stored energy along with the combustion characteristics of lithium batteries also constitute a significant safety hazard, potentially resulting in a thermal runaway fire. This hazard is particularly acute in the aviation field onboard the aircraft, and in particular the baggage and cargo hold, where fire hazards pose particularly severe safety risks to the aircraft.

For these reasons, the carriage of lithium batteries in checked baggage and cargo is tightly regulated and restricted by ICAO. Enforcing such regulation requires a means to detect the presence of lithium batteries. An opportunity lies with the use of imaging and detection equipment already deployed and required as part of aviation security infrastructure. With adaptations to its detection characteristics as well as operational adjustments, certain aviation security detection equipment can be made to also mitigate the specific safety risk posed by lithium batteries deemed non-compliant with the provisions for transport by air.

Description of work

In December 2022, EASA appointed a consortium to deliver this research study for the specific case of detecting lithium batteries in checked baggage. The consortium is led by Rapiscan Systems and supported by consortium partner UK CAA International. This project will consist of four technical tasks.

- Task 1: Review of state-of-the-art solutions, development of test plan and protocol and consultation with Stakeholders
- Task 2: Performance of tests, collection of data
- Task 3: Analysis of tests performed, consultation with Stakeholders
- Task 4: Conclusions and recommendations

In addition to the technical tasks, this project includes a fifth workstream: **'*Communication, dissemination, knowledge-sharing and stakeholder management*'.** As per the tender specification, the objectives of this workstream are to identify the target audience and their different needs and support EASA in the planning and organisation of the stakeholder events as well as in the preparation of briefings and presentations. The project will include several consultations with the main Stakeholders concerned with the detection of lithium batteries at aerodromes. Two workshops with Stakeholders need to be organised by the contractor during the project to present the results of Tasks 1 and 3.

Toward the end of the project, the dissemination of the research results is to be structured in a way that allows the contractor and EASA to identify the best communication formats and means to transfer the knowledge gained according to the identified dissemination goals. The dissemination goals range from ***raising awareness of the research project*** to the final goal of ***establishing a long-term impact of the project results on its target group***. Such goals, as well as the audience to be reached will be identified jointly by the

contractor and EASA and documented in the communication and dissemination plan. The plan shall also consider appropriate knowledge-sharing actions for the target group.
The deliverables under this workstream include:

- D-5.1 Communication, dissemination and knowledge-sharing plan and actions
- D-5.2 Stakeholder management plan and actions
- D-5.3 Final report

This report represents the deliverable for Task 1 – State of the Art Solutions.

Results and Application

The purpose of this overall study is to provide objective data and recommendations concerning the use of certain existing security screening equipment to detect lithium batteries in passenger checked baggage. By exploring this data, we will in turn assess the impact that detecting lithium batteries has on airport operations and screener performance. The results will be used to facilitate and underpin future discussions amongst stakeholders and regulators. At the time of writing, there is no plan to mandate the results of this study in European aviation regulation but, instead, to contribute to a discussion on any potential need to do so.

This part of task 1 will review the stakeholder consultation held for the first phase of the project.

The outcome of Task 1 will show the state-of-the-art solutions, development of test plan and protocol and consultation with Stakeholders. The results of this will be used to shape the subsequent project tasks 2.

CONTENTS

ABBREVIATIONS

ACRONYM	DESCRIPTION
ACI	Airports Council International – European Airport industry Association
BHS	Baggage Handling System
CAA	Civil Aviation Authority
CONOPS	Concept of Operations
DG	Dangerous Goods
EASA	European Union Aviation Safety Agency
EDS	Explosives Detection System
ECAC	European Civil Aviation Conference
EU	European Union
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organisation – Global Airline industry association
IED	Improvised Explosive Device
IT	Information Technology
Level 4	Level 4 is typically where passengers are reconciled with the aerodrome operator/air operator representative and their bag, should there be an issue. Level 1 is an x-ray scanner, Level 2 is a screener who views the scanner image should it be rejected, Level 3 is a screener with unlimited time to view a Level 2 reject
TIP	Threat Image Projection
Wh	Watt hours

1. Introduction

1.1 Scope and Objectives

Per the EASA contract, the main objective of the project is to evaluate the feasibility of the detection of lithium batteries transported in hold baggage using the security screening equipment and processes in operation at aerodrome operators. The project shall investigate the technical, operational and regulatory solutions to support safety-related requirements without affecting the performance of security operations as well as identify the main limitations, constraints and financial cost elements for their implementation at EASA Member States' airports. The project shall also study potential developments of technology and solutions for application to other transport scenarios (e.g., cargo, mail).

The project encompasses the performance, through a series of tests, of hold baggage screening equipment (explosive detection systems (EDS)) at an airport where traffic exceeds 1.5 million passengers annually. The aim of the trial is to demonstrate technical and operational solutions and assess the performances, limitations, and constraints for the detection of lithium batteries. The tests should also assess the impact on security performance and operations. The extension of the trials to the field of cargo screening can be limited to x-ray screening equipment.

Using security screening equipment with dedicated algorithms or software enabling or facilitating the detection of lithium batteries should be considered as one of the key elements of the project. Ideally, the equipment to be used should have already been tested in laboratory conditions before the operational trials. The project should also assess what additional resources and competencies are needed for screening personnel to perform additional duties and conduct an assessment in terms of training and resources required.

The following elements shall be considered for the development and implementation of the trials:

- Test criteria/threshold for detection of lithium batteries by screening equipment and security staff, incl. power banks and spare batteries and any battery contained in PED with capacity exceeding 100 Watt-hour.
- Methods for the performance of lithium battery detection in the airport operational environment, incl. technology solutions and working processes.
- Use of current market off-the-shelf detection solutions (e.g., software solutions) for lithium batteries,
- Combining explosive and lithium battery detection by the detection system with the same number of screening staff as being used for security screening operations.
- Potential use of similar solutions for the detection of other items that potentially pose a threat even if not directly caused by the battery, such as electronic cigarettes, vaping devices.

The main outcome of the project is to assess the valid and cost-effective technical, operational and regulatory solutions to be used for detecting lithium batteries in hold baggage, while considering additional potential safety benefits for other transport scenarios (e.g., cargo, mail).

An impact assessment of the proposed detection of lithium batteries on security operations performance for the screening of hold baggage shall be performed and presented. An initial impact assessment for cargo operations is also expected. The objective of the Test Plan is to detail the actions necessary for the development of the algorithm, operational test planning and data to be collected, as defined by the research project.

This document's objective is to report on the state-of-the art solutions for the detection of lithium batteries adapted to current hold baggage screening equipment and working procedures applied to European aerodrome operators.

1.2 Executive Summary

This report focuses on the state-of-the-art solutions available to aerodromes for the detection of lithium batteries in hold luggage.

Research undertaken for this project clearly shows that prohibited lithium batteries in checked baggage are making their way onto the aircraft. The potential dangers associated with lithium batteries are well documented and have been the cause of numerous in-flight fire incidents[1]. In June 2022, the International Air Transport Association (IATA) in order to address incidents with undeclared or mis-declared shipments of lithium batteries called on governments to further support their safe carriage by developing and implementing global standards for screening, fire-testing, and incident information sharing[2].

The consensus from this research project is that passengers are often unaware of the risks posed by lithium batteries and ignorant to the fact that an item in their checked baggage contains a lithium battery. Even though the online and aerodrome check in highlights prohibited lithium batteries, they are still being transported on board aircraft.

If all checked baggage was to be screened for lithium batteries, an automated system would certainly be necessary. The throughput at all but the smallest of aerodromes would be too great for screening of all bags using x-ray equipment. Fortunately, most aerodrome operators throughout Europe are using EDS equipment. Their primary purpose is to screen for explosives, however, these same systems could be used to screen for lithium batteries. EDS equipment has already demonstrated it can run additional algorithms to detect DG, firearms, narcotics, endangered animals etc. This report goes through the State-of-the-Art Solutions in-use today and concludes that an algorithm to detect lithium batteries is feasible and its deployment relatively straight forward. Other options covered under the Research and Development part of this report seem to be promising but either not yet mature or simply not pragmatic to be implemented during everyday operations of a busy aerodrome.

In summary, lithium batteries pose a safety risk, checked baggage containing prohibited lithium batteries will make it onto the aircraft as most go unscreened by a human operator. Air operators, aerodrome operators and regulators from across the safety and security communities are acutely aware of the risks. If this is seen as a significant risk then what would be needed are actions to drive change. Fortunately, EDS equipment is

[1] Lithium aircraft incidents on the rise - CBS News Report
Battery fire on board aircraft - ABC New Report
International Association of Fire and Rescue Services - News Report
Aircraft fire on board Cainiao - News Report
Bicycle battery fire - Sky News Report

[2] IATA - Government Support Needed to make Transport of Lithium Batteries Even Safer

already present in most EU aerodromes, and if it were determined that screening is needed based on risk and operational feasibility then the equipment could be adapted to provide a solution.

1.3 Introduction

The motivation for this report is to help drive change to mitigate the risk associated with the transport of lithium batteries in checked baggage and the growing number of in-flight incidents.

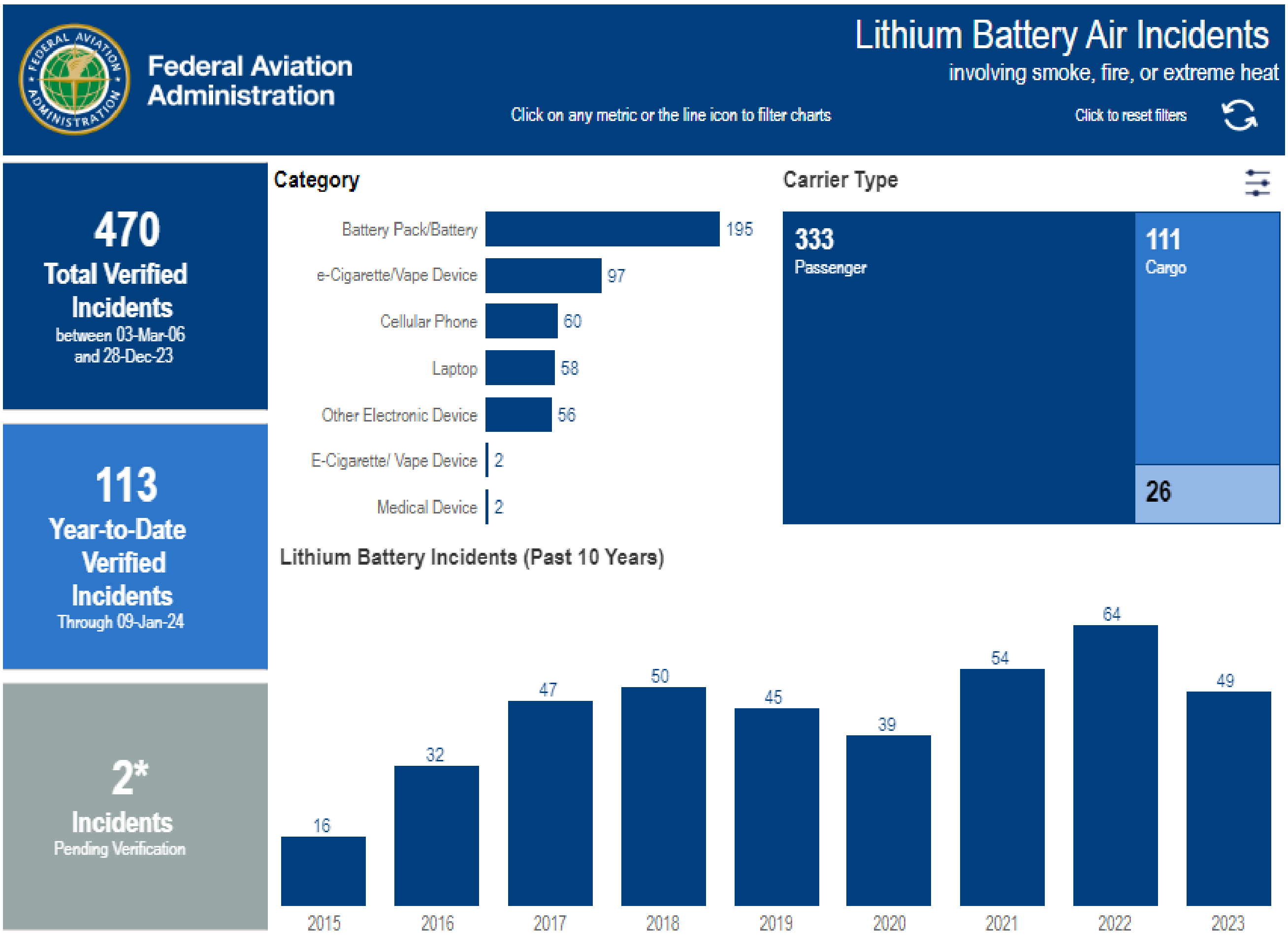
Aviation safety regulators and air carriers through IATA have been advocating for additional actions but a workable solution is yet to be found.

The report looks at technologies available today, capable of automatically detecting lithium batteries and some technologies still in their development stage.

With the exponential growth of lithium batteries powering so many everyday electronic devices it is inevitable that they will be placed in checked luggage, either by themselves or in electronic devices.

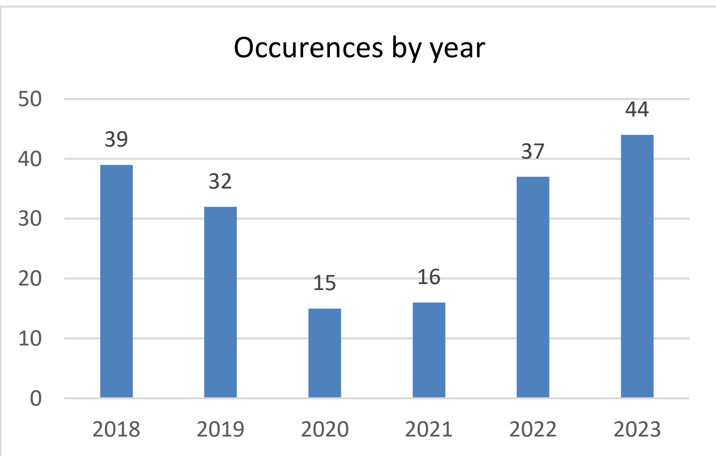
Forbes Magazine published an article in March 2023 (Forbes Magazine Lithium Battery Incidents) regarding the growing number of lithium battery incidents. The US Federal Aviation Administration (FAA) reported 62 lithium battery overheating incidents in 2022 compared to 54 the previous year. The article went on to state that in 2014, only 9 incidents were reported all year, highlighting the growing use of lithium batteries and the risk associated with them.

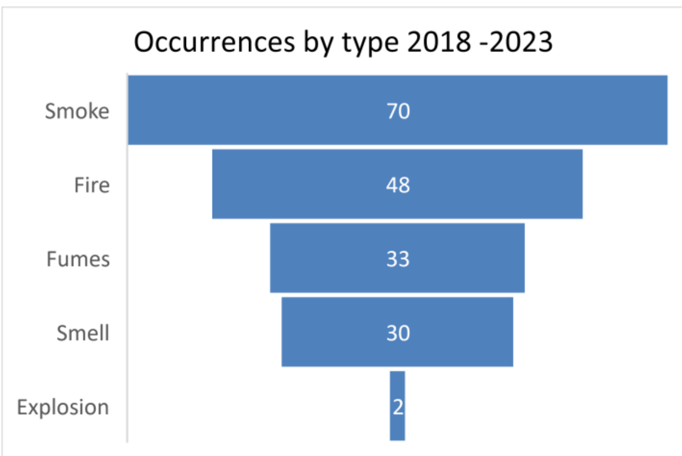
The FAA report shows after lithium batteries, e-cigarette and vape devices are the number two cause of air incidents involving smoke, fire or extreme heat (see diagram below).



Source: Federal Aviation Administration, Security and Hazardous Materials Safety

The data below is from the European Central Repository for the period 2018-2022 and as the FAA data, shows the number of lithium battery incidents.





Source: European Central Repository

Without extensive research across multiple aerodromes, it is impossible to know the extent of undetected prohibited lithium batteries making their way to the aircraft. However, during the industry interviews, one aerodrome operator conducted a study and found that just over 1% of checked baggage contained some form of prohibited lithium batteries. IATA report that, globally, there are ca. four billion items of checked baggage per year, using 1%, this would equate to 40 million bags containing prohibited lithium batteries.

A recent fire on the vehicle transportation ship, Freemantle Highway, demonstrates the risk of lithium batteries. The ship had 3,000 vehicles on board, including twenty-five which were electric. It is believed that the fire started with one of the electric vehicles. The crew were unable to extinguish the fire and had to be rescued from the ship. Tragically, one of the crew members died. An interview with the Director of CEDRE (French agency specialising in accidental water pollution) suggested that the insurers will be quicker than the authorities to "put some order" in place for the transportation of lithium batteries (Freemantle Highway Ship Fire).

1.4 Methodology

The source of material for this report has come from one-to-one interviews with aerodrome operators, air carriers and regulators, information published on the Internet and input from individuals at ICAO and ACI. This has been augmented with subject matter experts within Rapiscan Systems who have EDS deployed in many airports around the world, and consortium partner, UK CAA International.

The one-to-one interviews were particularly useful to understand any processes employed to identify lithium batteries, the techniques used and any thoughts they had on detection.

Rapiscan also reached out to the other EDS suppliers to determine if they have a lithium detection algorithm for checked baggage and if they did, feedback on their experiences and if any EU aerodromes are using them. Suppliers contacted included Smiths Detection, Nuctech, Leidos and SureScan. Responses were received from Smiths Detection and Nuctech.

1.5 Background on Lithium Batteries

Lithium batteries are Class 9 hazardous materials. They come in several common formats, including cylindrical (such as AA, 18650), prismatic (or brick-shaped) and pouch cells (highly customisable). They are used in the vast array of electronic devices either in singular (cell phones) or multiples (power tools).

Lithium batteries can be presented on their own (package only contains batteries), packaged with (package contains equipment, with lithium batteries separate), contained in (the batteries are installed in the equipment), vehicles and cargo transport unit.

For checked baggage, IATA only allows lithium batteries to be contained in personal electronic devices or personal medical devices up to 160 Wh. No spare lithium batteries are allowed. For perspective, 100 Wh can be reached with 8 x 18650 cells – equivalent to the size of a modern smartphone, albeit double the thickness.

Lithium batteries are found in smart phones, laptops, tablets, smart watches, power banks, e-bikes/scooters, cameras, power tools, toys etc., most of which can conceivably be contained in checked baggage.

The table below shows the IATA guidelines (DGR-64-EN-RGB) used by the air operators to advise passengers on lithium battery limits (e.g. BA DG Guidelines). The information is far from simple and understandable how it could confuse passengers. The lithium battery limits are displayed in Watt hours (Wh) and grams, however, not all lithium batteries or powered devices display this data.

Wh rating or lithium metal content	Configuration	Carry-on baggage	Checked baggage	Operator approval
≤ 100 Wh / 2g	In equipment (PED or PMED)	Yes (max 15 PED/PMED[1])	Yes	No[1]
	Spare battery(ies)	Yes (max 20 spare batteries[2])	No	No[2]
>100 to ≤160Wh	In equipment (PED or PMED)	Yes	Yes	Yes
	Spare battery(ies)	Yes (max 2 spare batteries)	No	Yes
>160Wh	Must be prepared and carried as cargo in accordance with the IATA Dangerous Goods Regulations			
> 2g ≤ 8g	In equipment (PMED only)	Yes	Yes	Yes
	Spare batteries for PMED	Yes (max 2 spare batteries)	No	Yes

1. Each person is limited to a maximum of 15 PED. The operator may approve the carriage of more than 15 PED.
2. Each person is limited to a maximum of 20 spare batteries of any type. The operator may approve the carriage of more than 20 batteries.

Source – IATA "Passengers Travelling with Lithium Batteries"
PED = Portable Electronic Devices, PMED = Portable Medical Electronic Devices

Other items covered by IATA include spare batteries, electronic cigarettes containing lithium and ‘smart’ baggage with integrated lithium.

ICAO technical instructions for the transport of lithium batteries by passengers and crew are very similar to those of IATA. They too state gram and Wh limits on lithium batteries but go further by stating that batteries contained in portable electronic devices should ideally be carried as carry-on baggage.

Lithium batteries are considered safe during normal use, but can present a fire risk when over-charged, short-circuited, submerged in water, damaged, or resulting from poor manufacturing. They are a low probability cause of fires, but when fires do occur there can be severe consequences.

1.6 State-of-the Art Solutions

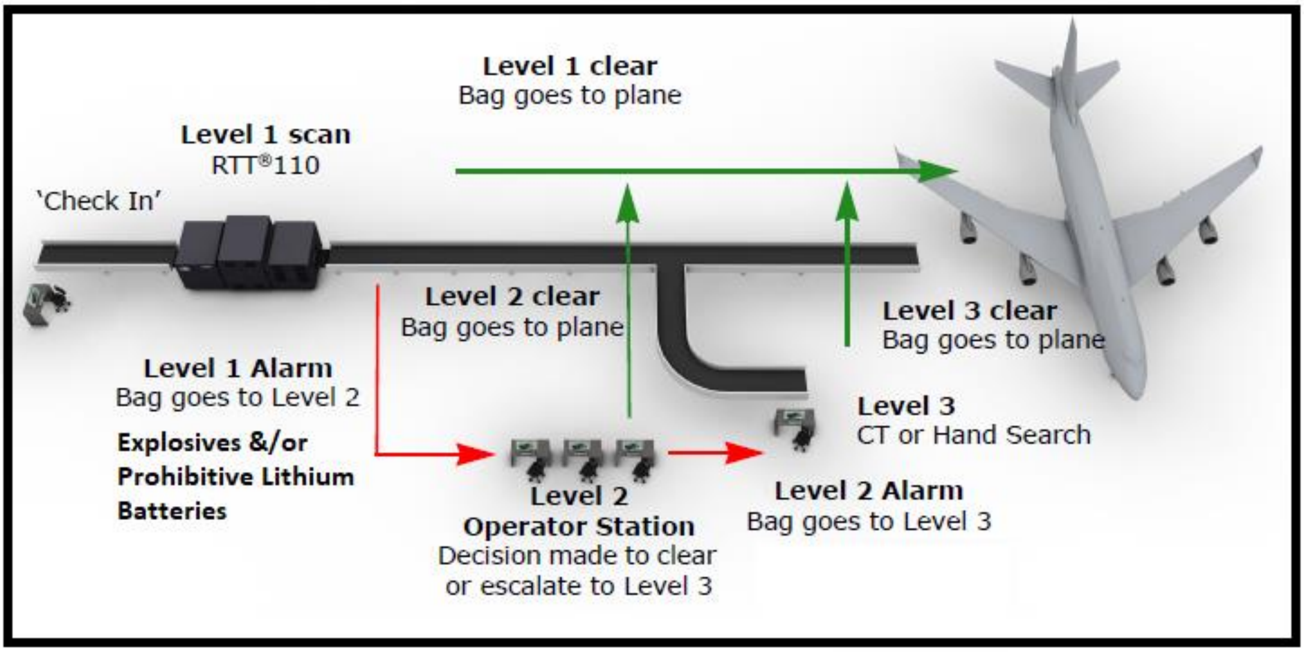
If aerodrome operators were to voluntarily implement or were to be regulated into performing one hundred percent screening for lithium batteries, the volumes of checked baggage would require an automated system. For some time, X-ray equipment used at the checkpoint for cabin baggage inspection, have had the ability to identify lithium batteries (e.g. Smith Detection Lithium Battery Detection Checkpoint). This is ideal, as the investment for the X-ray equipment has already been made to check for explosives, weapons etc. Adding lithium battery detection capability is relatively inexpensive and it fits into existing airport processes.

Much like cabin baggage screening, a logical step and, likely, the least expensive solution for aerodrome operators would be utilising their existing EDS equipment and add a lithium battery detection algorithm. Smiths Detection, Rapiscan Systems and Nuctech have all developed some form of dangerous goods detection including lithium batteries, (Smiths Detection example: EDS Lithium Detection). As part of this project Rapiscan Systems will further develop a specific lithium battery detection algorithm for its RTT110 product and conduct trials at an aerodrome.

A potential Concept of Operations (CONOPS) for EDS equipment is shown below and how it could be adapted to include a check for lithium batteries. The EDS equipment scans (Level 1) the baggage for explosives. If none are found, the bag goes straight to the aircraft. If the EDS identifies a potential explosive, the X-ray image, highlighting the area of interest in the bag, is sent to a screener to review the image (Level 2). If it is cleared by the Level 2 screener the bag goes to the aircraft. If the Level 2 screener is unable to clear the bag, it then gets passed to a Level 3 screener who has more time to review the bag and can utilise additional technologies to determine if an explosive is present. They can also reconcile the bag with the passenger.

To add lithium batteries the screeners would review the X-ray image in much the same way as for explosives. The EDS would generate an image, highlighting the area(s) of interest and the Level 2 screener would review and clear to the aircraft or reject to Level 3. At Level 3, the bag would need to be opened with the passenger present and determine if there are prohibited lithium batteries present, unless the aerodrome can open baggage without the passenger in attendance.

It could be, that if acceptable to regulators, additional duties to resolve lithium battery alarms could be given to existing security staff or images with lithium battery alarms could be sent to dedicated safety screeners. Similarly, rejected bags could be sent to the current Level 3 area or additional safety alarm resolving areas (and baggage diverts) could be put in place specifically to deal with undivested lithium batteries.



Extra screeners would be needed to review the additional images generated by the lithium battery detection algorithm. We can use - Duesseldorf Airport (see table below) as an example. It saw 5,920,635 passengers in May 2023. This could equate to an additional 251 bags/hour needing to be screened, with 42 bags needing to be opened and potentially reconciled with passengers depending on the procedures in place at the location in question.

# Passengers March 2023	40% Checking in a bag	# Bags/Hr (over 18 hours)	5% Li battery alarms (per hr)	5% Bags need to be opened (per hr)
1,228,000	491,200	27,289	1,364	68

Source: European Organisation for the Safety of Air Navigation (Eurocontrol) (online data code: avia_tf_cm)

Example given is Duesseldorf aerodrome data for April 2023. Assumption is 40% of passengers check in a bag. The lithium detection algorithm alarms rate is 5% of all bags. 5% cannot be resolved by the screener and require the bag to be inspected.

To ensure that screeners and aerodrome operators can manage the volume of rejected bags caused by the lithium battery detection algorithm, suppliers, aerodromes, and regulators may need to identify the ideal threshold of lithium batteries for the EDS equipment to alarm (real and false) on. The lower the specified mass the higher the probability of false alarms. It is also possible to introduce random checks for lithium batteries in order to balance additional workload based on the risk appetite of a given air carrier and local arrangements in place.

It is also important to note that EDS equipment will not detect 100% of lithium batteries; there will always be an inherent false negative rate as with most detection capabilities. If 100% detection were required, then the false alarm rate and subsequent operational impact would likely be prohibitive. Based on the level of acceptable risk and what would be practical in terms of detection performance a specification would have to be developed by relevant stakeholders in terms of the best combination of acceptable size / quantity of batteries, acceptable false alarm rates and desired detection rates.

Further, EDS equipment will likely be unable to identify if any lithium batteries detected are permitted or prohibited. The IATA DGR states a Portable Electronic Devices containing a Lithium ion battery with a 100 Wh rating is permitted in checked baggage, but a spare lithium battery with the same Wh rating is prohibited. The EDS algorithm may identify the lithium battery but not be able to determine if it is contained in an electronic device or on its own. It may be that the algorithm will generate an alarm on all lithium batteries, relying on a screener when reviewing the image to clear or reject it. If the screener is unable to ascertain this from the image, the bag would need to be opened. As already mentioned, this could be a challenge as not all electronic devices display their Wh rating.

EDS equipment can provide an operationally efficient solution and reduce the risk caused by lithium batteries, but they do have limitations. They are already in place in most aerodromes in Europe and the aerodrome operators' CONOPS can be expanded to include lithium battery detection.

1.6.1 State-of-the-Art Solutions Available Today

Due to the large number of checked bags processed at an aerodrome (comfortably up to 1,000 bags/hour, per line), the solution must be automated, be able to deal with typical conveyor speeds of 0.5m/s, be quick in deciding (typically <2 seconds) if lithium batteries are present in the bag, accurate (a low false alarm rate), easy to integrate into existing CONOPS and affordable. Only CT-based EDS equipment fit this criterion. Conveniently, the majority of EU aerodromes are already using these systems to detect explosives. Adding a lithium battery detection algorithm, should the manufacturer have one, is relatively simple.

An EDS machine is a computed tomography based X-ray machine which detects explosives by looking at the density of items contained in a bag. The EDS machine is incorporated into the aerodromes baggage handling system, transporting passenger baggage from check-in to aircraft. The bag data collected by the EDS machine is processed and fed through an algorithm. If the algorithm detects an explosive (real or false), the EDS sends the image to a PC-based terminal for a person (screener) to inspect. If the screener clears the bag it goes to the aircraft. If not, it goes to further levels of inspection until it is cleared or repatriated with the passenger and opened.

In addition to Rapiscan, there are four providers of EDS machines comprising Leidos, Nuctech, Smiths Detection and SureScan.

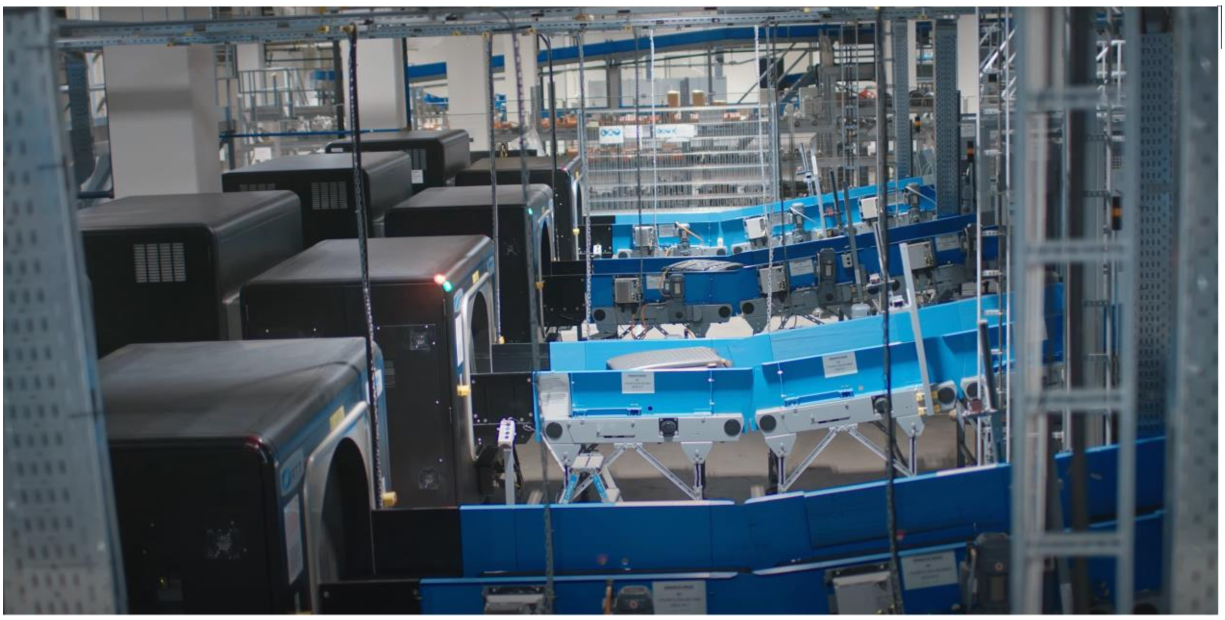


Image 1 - shows a baggage handling system conveying passenger baggage through four Rapiscan EDS machines, screening for explosives.

Image 2 – shows a bag going through the EDS machine.

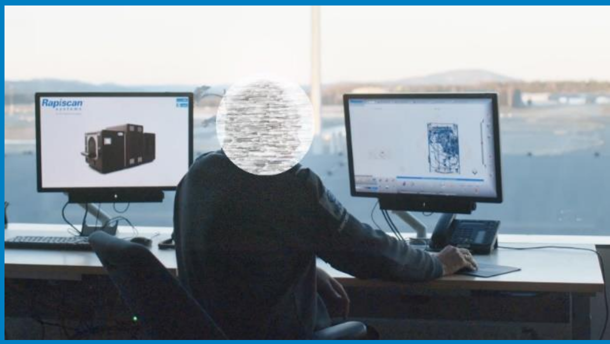


Image 3 - shows a screener viewing an alarmed bag image (screener's face has been obscured for privacy).

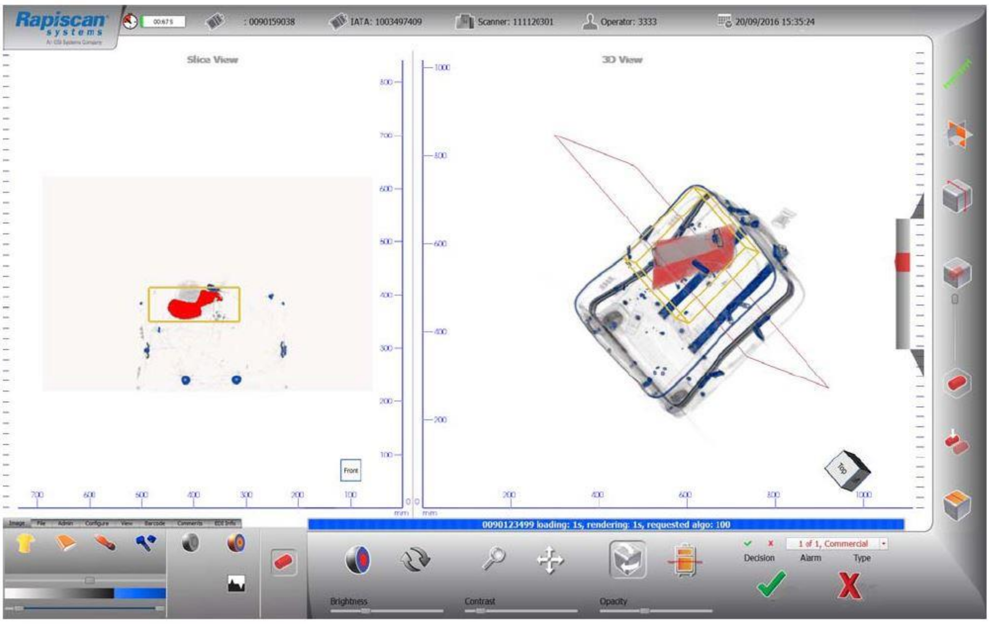


Image 4 - shows a typical screener graphics user interface (GUI). The 3D bag image can be manipulated using tools to determine if the alarmed object in the bag is a false alarm or a potential threat.

There are considerations for the aerodrome in advance of adding a lithium battery detection algorithm to their EDS machines, chiefly, the extra alarm volume needing to be viewed by screeners. It would, therefore, be prudent for the aerodrome to first run simulations and trials to establish the extra load for the screener group. A trial would have the added benefit of stress testing any new processes and procedures resulting from the additional algorithm. Alarm volumes will very much depend on the aerodrome and what their passengers put in their checked baggage, which is why pre-testing is recommended.

The aerodrome may also consider the creation of a separate screener group, dedicated to resolving lithium battery alarms so as not to distract from resolving the critical explosives alarms. This additional group could be staffed and managed by the aerodrome or the airline carriers.

1.6.2 EDS Manufacturer Feedback

The EDS manufacturers, comprising Leidos, Nuctech, Smiths Detection and Surescan were contacted as part of this project. They were each sent a lithium battery algorithm questionnaire. Responses were received from Nuctech and Smiths Detection.

Rapiscan, Nuctech and Smiths Detection have each developed a lithium battery detection algorithm. However, the usage of the algorithm fairly limited and in use at only three small EU aerodromes. Data from these aerodromes show that detection rates are high, at around 85 percent, while false alarm rates are low averaging less than 5 percent. For a non-regulated algorithm, this level of performance is impressive and demonstrates what can be achieved with EDS machines.

Smiths Detection offer a lithium battery algorithm as part of their iCMORE (link: iCMORE) suite. iCMORE also includes guns, gun parts, ammunition and knives and is available with the HI-SCAN 10080 EDS machine. They claim little or no screener training is needed, a high probability of detection and low false alarm rate. In addition to lithium batteries, the algorithm also detects flammable liquids and solids and liquified and compressed gases.
The algorithm identifies a diverse range of separate and packaged battery types such as AA/AAA, mobile phone batteries and larger items such as power banks, power tool batteries etc. It is currently operational in one small EU aerodrome. They are using the algorithm more as a screener aid rather than in an automated way.

Smiths noted that there can be challenges implementing the additional algorithm into existing screening systems and have faced some resistance from airlines when implementing the necessary processes.

Image 5 – Smiths Detection EDS HS10080XCT

Nuctech's lithium battery detection algorithm (link: Nuctech) much like Smiths Detection, is used infrequently in the EU. The countries using it tend to be the ones where civil aviation authorities have implemented and are enforcing lithium battery restrictions. Nuctech states that the algorithm provides high probability of detection and a low false alarm rate. Nuctech's non-regulated algorithm options also include narcotics.

Rapiscan offers a Fast Parcel dangerous goods algorithm (lithium batteries, flammable liquids and compressed gases) and is in use on nearly forty of its EDS machines around the globe. Safety concerns over dangerous goods, including lithium batteries, is particularly heightened in this industry as many of the companies own their aircraft fleet. Operational performance is good, much like Smiths Detection and Nuctech. Screener's view images for both explosives and dangerous goods and images review times are very reasonable given the addition of a second algorithm.

Also available in Rapiscan's suite of non-regulated algorithms is firearms, wildlife trafficking and bio-security. Bio-security demonstrates the art of the possible and what can be achieved with EDS machines. In addition to a wide range of meat, fish and seafood, vegetable and plant foods, the algorithm detects of fruit, including apples, avocado, banana, blueberry, grape, kiwifruit, lemon, lychee, mandarin, mango, orange, plum, strawberry and tomato. This algorithm is used predominantly in Australia and New Zealand to safeguard its animals, plants, farms and the environment from pests, diseases, and weeds. Australia and New Zealand take bio-security very seriously and relies on Rapiscan's EDS to help police its borders. This is a good example of a governmental requirement driving an EDS manufacturer algorithm development and successful deployment into aerodromes.

The additional algorithm can be either be loaded onto the EDS machine as it leaves the factory or installed post installation at the aerodrome. Loading the algorithm onto the machine takes only a few minutes. Customers should consider whether they precure a one-off algorithm or to work with the manufacturer and optimise it over time to their stream of commerce. Where throughputs are high, even a small reduction in false alarm rate can represent a considerable reduction in screener resource (costs).

Pricing is commercially sensitive but would likely include algorithm plus installation and commissioning, additional hardware (if needed), screener training. Relative to the problems they mitigate, non-regulated algorithms represent excellent value for money.

Screener training is relatively quick. The additional algorithm behaves in much the same way as the explosive detection algorithm (see figure 4) in that a bounding box on the GUI highlights the suspected lithium battery. Rapiscan uses a purple bounding box to highlight dangerous goods, including lithium batteries. The screener uses the same GUI tool set to identify if it is a false alarm, and clears the bag to the aircraft, or if it requires additional inspection, rejects it to the next security level.

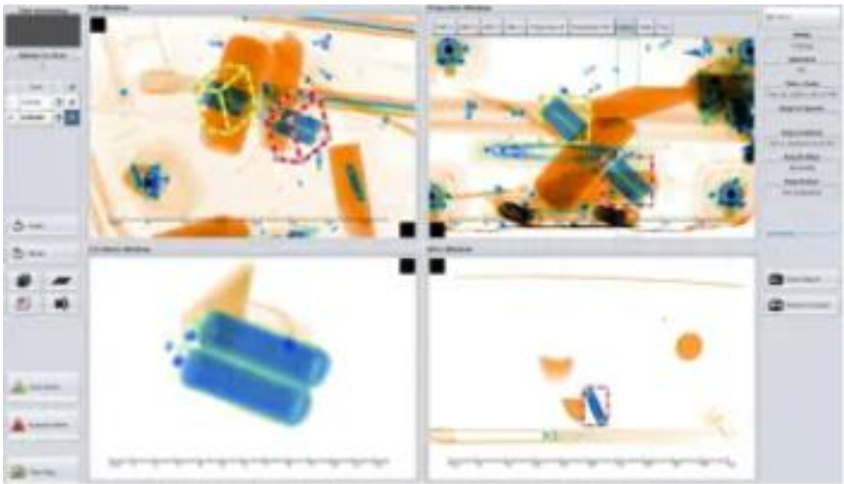


Image 5 – shows the Smiths Detection screener GUI displaying a lithium battery alarmed image.

Image 6 – shows Rapiscan screener GUI highlighting a lithium battery alarm image and the actual item found (power tool battery).

A tremendous benefit with a non-regulated algorithm is that it does not require regulatory approval. This saves considerable time and cost, allowing manufacturers to work directly with customers. It also means that the manufacturer and aerodrome can work together to optimise the algorithm without lengthy periods of inactivity while it is being approved by a regulator.

It should be noted that algorithms developed for EDS are tailored to the machine and cannot be utilised in other computed tomography products such as those used at the checkpoint or for cargo.

Aside from EDS machines, there are interesting and possible solutions which may be available in years to come, but they are far from commercial use. They are covered in the Research and Development part of this report.

1.7 Research and Development

Aside from EDS equipment, the only other method encountered for lithium battery detection suitable for an aviation setting was the use of canine. Cargo handler Worldwide Flight Services and dog-handling detection firm Diagnose undertook a six-month trial using dogs to detect lithium batteries in cargo shipments (Using canine to find lithium batteries). It was reported that they achieved 100% accuracy.

However, it is unrealistic to consider using canine to detect baggage flowing at 0.5m/s for up to eighteen hours per day.

An interesting technology was reported in the Journal of Materials Chemistry. A sensor has been developed to identify damaged lithium batteries. The sensor is able to detect trace amounts of electrolyte and vapor leakage (Sensor detecting leakage), whose presence could indicate a damaged battery. It appears to be at the research phase and likely some time for it to be a commercial solution.

1.8 Conclusion

Lithium batteries, in themselves, pose a relatively low risk of fire. However, the ever-increasing use of lithium batteries inevitably means fire incidents will continue to occur and if not mitigated by additional preventive measures their number is likely to increase, with potential catastrophic outcomes if it occurs in-flight.

If we accept that passengers are fallible and pack restricted lithium batteries in their checked baggage and that the vast majority of checked baggage goes unchecked for lithium batteries and dangerous goods generally, then from a safety perspective, there is a strong argument that all baggage should be screened. FAA, IATA and EU incident data demonstrate the consequences of not doing this.

The regulators and industry are clearly aware of the risks posed by lithium batteries, however, only a relatively small percentage of baggage is screened to detect lithium batteries. ICAO and IATA have had clear guidelines for some years now but incidents continue to occur on a regular basis.

EDS equipment can provide a relatively inexpensive solution to this issue. They are already present in most aerodromes in Europe. EDS suppliers could quickly deploy a lithium battery detection algorithm to their fleet, enabling the aerodrome operators to begin screening all checked baggage for lithium batteries. Other options do exist and seem to be promising however they are not yet mature or feasible to be implemented for the time being. Consequently, and based on the work undertaken for this report, the deployment of a lithium battery detection algorithm would seem a pragmatic, quick and workable solution to a very real problem.

This project aims to further the understanding of what detection options may be feasible in the future to reduce the growing risk of lithium batteries carried in checked baggage. It is envisaged that this work will act as an instigator to the key stakeholders from across the safety and security community who may be able to influence and effect the implementation of a detection capability.

1.9 References

- IATA lithium battery regulations for checked baggage (DGR-64-EN-RGB)
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- Report on electric vehicle fire on board transport ship - Freemantle Highway Ship Fire
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- Nuctech – lithium battery detection algorithm for checked baggage capability ((EDS Lithium Detection)
- Using canine to detect lithium batteries in cargo - Using canine to find lithium batteries
- Sensor detecting electrolyte and vapor leakage from a lithium battery - Sensor detecting leakage

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