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FOCUS is a quarterly subscription journal devoted to the promotion of best practises in aviation safety. It includes articles, either original or reprinted from other sources, related to safety issues throughout all areas of air transport operations. Besides providing information on safety related matters, **FOCUS** aims to promote debate and improve networking within the industry. It must be emphasised that **FOCUS** is not intended as a substitute for regulatory information or company publications and procedures.

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Front Cover Picture: The photograph shows a Sea King HAR Mk3 of D Flt, 202 Squadron based at RAF Lossiemouth. With the formal disbandment of the RAF SAR Force on 18 Feb 16, it has been announced that the Sqn numberplate will be transferred to the Search and Rescue Training Unit (SARTU) based at RAF Valley as part of the Defence Helicopter Flying School (DHFS).

Safety and Security

by Dai Whittingham, Chief Executive UKFSC

Congratulations! 2015 was the safest year on record for commercial aviation. According to Ascend statistics there were just 8 fatal accidents for jet or turboprop aircraft (14 seats or more), with the loss of 161 lives; all these accidents involved local turboprop carriers and only 3 occurred on revenue passenger flights. The 2015 accident rate was approximately 1 per 5 million flights, with global fatality rates for revenue passengers at a remarkable 1 per 40 million. That is a great achievement, but the figures exclude the Germanwings and MetroJet accidents; both losses are attributed to acts of violence and cost 374 lives, a stark reminder that the safest operation in the world is still vulnerable to security lapses, and we should not forget the loss of MH17 or suspicions that the disappearance of MH370 may be security-related.

The 10-year moving average for fatal accidents is now 18.2, less than half of the rate (37.9) prevailing in the 1990s. If this rate is maintained until 2019, Ascend estimates 7800 fewer people will lose their lives compared with the 1990s. Notably, this year's rate is half the 10-year average and for western-built jets has improved to approximately 1 per 10 million departures. Western-built jets carried 3.7 billion passengers without accidental loss in 2015 year; even with Germanwings and MetroJet included, the odds of dying as a passenger last year were 1 in 100 million.

Paradoxically, this success on the safety front also brings twofold dangers: complacency, and commercial pressure to reduce spending on safety. Complacency is likely to be the easier problem to tackle because safety is now firmly embedded in the collective consciousness, and work on establishing a Just Culture environment is also starting to bear fruit in providing more safety information. That is not to say we can relax, far from it.

Commercial pressure is another beast entirely. In an industry where margins are so tight, it is no surprise shareholders apply pressure through management boards for costs to be reduced. It is always a pressure that has affected commercial aviation and it is not going to change. We see it in action with industry and Government pressing the CAA to cut the cost of regulation; the CAA, which operates as a commercial concern, is already under financial pressure and has few cost-reduction options other than trying to become more efficient and/or stopping some of the safety-related activities previously taken for granted. There are some obvious questions arising. At what point does that process tip the balance of risk versus cost? What level of safety is acceptable to the public, the Government, the people who deliver the service, or the people who invest or underwrite to keep our industry viable? Would it be OK to accept lower levels of safety than we enjoy today?

Weighing heavily in any cost-benefit analysis on safety is the fact we are actually very safe. Aircraft design and manufacture will continue to drive efficiency, reliability and safety into the system – product safety is a key selling point that has significant implications for the insurance market, which in 2015 saw costs outpace premium income for the third year running despite the reduced accident rate. It would be reasonable to assume the aviation insurance market will want safety efforts to remain robust. Nonetheless, it will be ever harder to argue at company level for safety enhancements that aim to squeeze us into a fraction of the last percent of the safety space. We can also expect to see some companies wanting to reduce spending on safety wherever possible, in response to shareholder demands.

Manpower is a primary cost driver in any business, especially when it must be highly trained; diverting line crews into safety activities is therefore not a cheap option but we can agree it is a necessary one if there is to be full understanding of the implications of some safety incidents, which is why the AAIB insists its ops inspectors maintain a current ATPL. The manpower pressure also manifests clearly in flight time limitation schemes – on the one hand the FTLs are there to protect against fatigue and on the other they produce a level of staffing that financiers often see as excessive.

A recent aviation journal article argued that the use of FRMS would make it harder to defend FTLs on pure safety grounds, leading to their redundancy as the safety benefit did not provide a return on the flight crew investment. Few would share the view that a decent FRMS allows you to operate with comparative impunity; the idea that your fatigue is being carefully managed, so you can therefore safely reduce manpower, does not hold water. There is a counter argument which suggests FTLs are not limiting enough because, even with FRMS in place, fatigue-related incidents and reports continue. One could argue that FTLs have in fact become targets rather than limits. The parallel is with the computer: if your processor (pilot) runs at 100% of its capacity (FTL) it crashes frequently and you end up spending money on a more capable system!

There is clearly more fatigue work to come as the new EASA FTL schemes bed in, and we can expect to see greater prominence given to sleep science. The Honourable Company of Air Pilots working group on fatigue is looking at all parts of the industry, not just the flight deck. The working group will also try to determine the proportion of part-time contracts; some pilots have taken this option for life-style reasons, but many others take it as a way of managing their fatigue. The economics are simple: for every 4 pilots on a 75% contract, the operator needs to employ one more to make up the shortfall, which comes with a significant training and manpower overhead bill. And part-timers need the same checks and recurrent training as full-timers. On the other hand, there are plenty of North Sea helicopter pilots who might be glad of a reduced-hours contract instead of selection for redundancy. In tough economic conditions, it is a brave man or woman who waves a fatigue flag or even calls in sick; this is a classic example of a known safety risk being exacerbated by financial pressure on both sides of the fence.
There are no 'quiet' jobs any more, as manpower levels inevitably at an absolute minimum. However, skimping on safety staff brings additional risks, not least that small but crucial signals (see the Winter 2015 editorial) may go undetected under the deluge of daily work. Stress from high workload increases sickness absences, contributes to staff turnover and detracts from efficiency. If

manning is so tight you can't release people for external safety-related activities, you end up operating in splendid isolation and potentially deny yourself the one piece of information that might prevent your next accident. It is always difficult to balance cost and safety, but the impact of getting the balance wrong can generate disproportionate costs. That balance is something that should always be given very careful consideration.

Which brings us back to security. The Germanwings and MetroJet losses were from very different causes but both security-related. There is plenty of ongoing work on crew mental health issues, though we need to avoid knee-jerk regulation that might be ineffective, too onerous or have unintended consequences - for example, there are understandable concerns about the '4 eyes' concept and the potential to bring relatively unknown people onto the flight deck. Remember that suicide is rare but murder as part of a suicidal act is very rare, and rarer still in the aviation environment. The exception is the suicide bomber scenario, which is security, not mental health-related.

The need for improved physical security will have an increasing impact on operations. We have recently seen two aircraft attacked by terrorist bombs: the MetroJet A321 and the Daallo A321 at Mogadishu. While the latter incident is still under investigation, photographs and eyewitnesses leave little room for doubt as to its cause. Worryingly, it appeared to involve a suicide bomber and a device handed over after the passenger had passed through security screening. The Lockerbie and Air India bombings proved screenings at that time were inadequate, and much effort has since ensured major international hubs are well-protected with the latest technology and screening techniques. But such security efforts prove fruitless if weak physical security measures allow easy airside leakage for terrorists and their paraphernalia.

Granted, security measures in airports might be circumvented, and there have been several recent attempts to achieve this (such as the liquid bomb plot) but the biggest threat arguably lies in areas where terrorism is commonplace. If our response is to limit risk by avoiding such areas, the unintended consequence may be a reduced inward flow of capital producing conditions that foster more terrorists. It is a vicious cycle.

For the travelling public, safety and security are synonymous; they simply want to survive the trip. We need to reassure them that everything is being done to achieve that goal, so we need to balance security with safety, and both need to be balanced with cost. We can't operate without some inherent risk, but being too safe and secure could mean a non-viable operation. We have come a long way in improving both safety and security, and rightly so, but are we now safe enough to allow greater concentration on security? We will be wrestling with the question of that particular balance for a while yet.

Are we now safe?

by Chris Brady, Chairman UKFSC

As I write this column the International Air Transport Association (IATA) has just released data for the 2015 safety performance of the commercial airline industry. Globally, there were no jet airliner accidents involving passenger fatalities and only 4 turboprop hull loss accidents involving passenger fatalities. The five-year average rate for both is also down. This is undoubtedly very good news and something that the industry can be proud of.

The caveat to these stats are that acts of terrorism, suicide, non-passenger flights and flights in which no passengers are killed even if the aircraft is written-off are not included, so the Germanwings Airbus A320, Metrojet Airbus A321 and Services Air Airbus A310 are excluded from the data. The pros and cons of these exclusions very much depends upon where you are in the industry and what you are trying to measure. At the risk of over-simplification; as a manufacturer or operator it is of huge importance to know if the event was preventable in case your product or SOPs need to be improved. As a passenger or relative it matters little why your aircraft crashed, only that it did. IATA is a passenger body therefore its focus is on passenger fatalities. UKFSC members operate all types of flights and are as subject to terrorism and suicide as anybody else.

As crew anything that can cause an incident or accident needs to be considered. This extends beyond traditional flight safety events to security (Metrojet 9268, MH17), mental health (Germanwings 9525 & others), fatigue (Colgan 3407), lasers (Virgin 25), food poisoning (DL60), distraction flightdeck/industrial/domestic (Various), etc etc. Imagine a world in which no aircraft are lost from traditional safety events but they are still being brought down by terrorism or suicide. Would/could we still say that the hull loss rate was zero? I think not. Most organisations SMS will try to identify every credible risk and mitigate against it, this includes all of the above and many more. So we must not exclude any types of events or types of flights from the stats as this will only distort the data and give a false sense of security.

Entering the Wild Kingdom

by Ed Brotak

The worst U.S. military bird strike accident occurred on Sept. 22, 1995, when an Air Force Boeing E-3 (top) crashed shortly after takeoff from Elmendorf Air Force Base in Anchorage, Alaska, killing all 24 crewmembers.

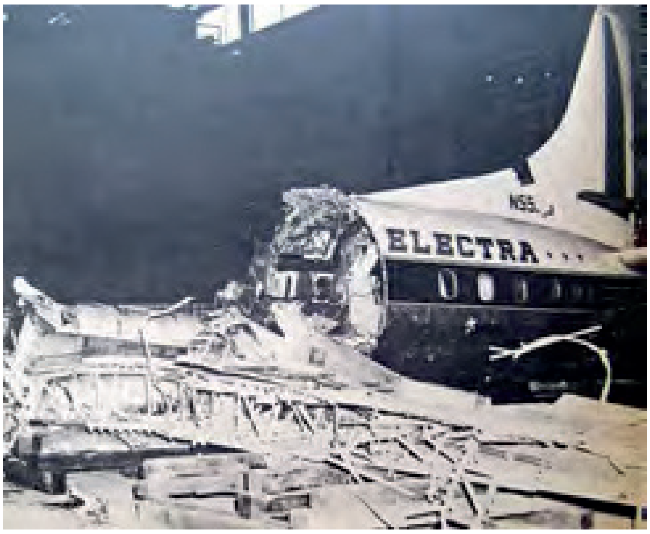
On the evening of Jan. 8, 2014, a U.S. Air Force (USAF) Sikorsky HH-60G Pave Hawk helicopter took off from RAF Lakenheath in the United Kingdom. The U.S. crew of four was practicing a nighttime rescue mission and was flying the aircraft about 110 ft above ground level (AGL) at 110 kt when they inadvertently passed over Cley Marshes, a nature reserve well known for its resident bird populations. Apparently startled by the noise of the aircraft, a flock of geese took off into the path of the helicopter. Several birds crashed through the windscreen, hitting the pilot and copilot and rendering them unconscious. At least one other bird hit the nose of the aircraft, disabling the trim and flight stabilization systems. The helicopter crashed to the ground in seconds, killing the pilots and two other crewmembers. The aircraft was destroyed.

Bird strikes have been a serious problem since the beginning of powered flight, according to a number of historical information resources. The first bird strike ever recorded was noted by Orville Wright in his diary in 1905, after his Wright Flyer struck a bird while flying over a cornfield in Ohio. Apparently, there was no damage to the airplane. The first recorded bird strike fatality occurred April 3, 1912, when an airplane flown by aviation pioneer Cal Rodgers — who in 1911 had become the first person to fly across the United States — collided with a seagull during a demonstration flight near Long Beach, California, U.S. Rodgers was killed after he lost control of the airplane, and it crashed into the Pacific Ocean.

The worst bird strike accident in terms of loss of life occurred on Oct. 4, 1960. Eastern Air Lines Flight 375, a Lockheed L-188 Electra, had just taken off from Logan Airport in Boston when it flew into a flock of starlings at an altitude of 120 ft. Three of the airplane's four turboprop engines ingested one or more birds, drastically reducing power and resulting in the shutdown of one engine. The loss of thrust and airspeed, and the asymmetry of the thrust, caused the pilots to lose control of the airplane, which crashed into Boston Harbor, killing 62 people.

But the most famous recent bird strike accident had a "happy ending" for the airplane occupants. US Airways Flight 1549, an Airbus A320-200 with 155 people on board, struck a flock of Canada geese shortly after takeoff from New York LaGuardia Airport on Jan. 15, 2009. Enough of the birds were ingested to cause loss of thrust in both engines. Chesley Sullenberger, the captain, and Jeffrey Skiles, the first officer, safely ditched the gliding airplane in the Hudson River in what was called the "miracle on the Hudson."

The military also has had its share of bird strikes. The worst such U.S. military accident occurred Sept. 22, 1995, when a USAF Boeing



An Eastern Air Lines Lockheed L-188 (above) crashed in 1960 after flying into a flock of starlings shortly after takeoff from Boston's Logan Airport.

E-3 Sentry airborne warning and control system (AWACS) aircraft, taking off from Elmendorf Air Force Base in Anchorage, Alaska, encountered a flock of Canada geese. Both port side engines lost power due to ingested material. The airplane crashed 2 nm (4 km) from the runway, killing all 24 on board and destroying the airplane.

Birds aren't the only concern. While taking off or landing, pilots occasionally have to contend with terrestrial animals that have wandered onto the runway. On Nov. 17, 2012, a Cessna Citation II being used by U.S. Customs and Border Protection was on a landing rollout at the Greenwood (South Carolina) County Airport. A deer ran out from the woods and struck the airplane on the left side above the left landing gear, rupturing a fuel cell. The spilling fuel caught fire. The pilot stopped the airplane, and the crew safely evacuated. However, the ensuing fire destroyed the airplane.

To better understand the magnitude of the wildlife strike problem in the United States, the Federal Aviation Administration (FAA) in 1990 began requesting that pilots and airport personnel report all strikes, regardless of damage. Today, reports can be filed electronically using a website <wildlife.faa.gov/strikenew.aspx> or on paper. To try to determine what types of wildlife are being encountered, the official "Wildlife Strike Report" requests that reporters identify the particular species involved in the strike. If identification of a struck bird/other animal is impossible but the remains are available, they can be sent to the Smithsonian Institution's Feather Identification Lab, where experts can determine the species of bird involved. Other countries have similar programs.

In 1995, the FAA, in conjunction with Department of Agriculture Wildlife Services, started work on a wildlife strike database. The FAA serial report "Wildlife Strikes to Civil Aircraft in the United States" first was published in 1996 and is issued every year. The latest report was released in August 2015 and covers the period from 1990 through 2014 <www.faa.gov/airports/airport_safety/wildlife/media/Wildlife-Strike-Report-1990-2014.pdf>.

Its statistics provide a clearer picture of the wildlife problem for aviation in the United States. The number of reported strikes increased from 1,851 in 1990 to a record 13,668 in 2014, partially because pilots have become more receptive to the reporting procedure. However, it should be noted that bird populations — especially those of larger birds — have increased in recent years, as has air traffic. Also, it is believed that because newer turbofan-powered aircraft are quieter than transport jets of earlier years, they are less recognizable to birds. Keep in mind that the data represent only strikes that were officially recorded and underestimate the actual numbers (ASW, 6/15, p.34).

A deer ran out of the woods and struck a Cessna Citation II that had just landed, rupturing a fuel cell. The crew escaped but the airplane was destroyed by fire.

Most wildlife strikes cause no damage. In 2014, 581 strikes, or 4 percent of all reported strikes, resulted in damage to the aircraft. And the number of damaging strikes actually has decreased 24 percent since 2000, likely due to wildlife strike–prevention efforts. The decrease occurred for commercial air transport aircraft, not general aviation (GA) aircraft, where the damaging strike rate has remained fairly constant. However, this still leaves a significant problem. Between 1990 and 2014, 67 aircraft of all categories were destroyed or damaged beyond repair by wildlife strikes. More than 60 percent of these were smaller GA aircraft.

Noting that a precise estimate of monetary losses is difficult, the latest report estimated that in 2014, wildlife strikes resulted in 172,151 hours of down time and $208 million in direct and indirect

costs. But the report also said that “actual costs are likely two or more times higher than these minimum estimates.” Over the 25-year period covered by the data, 12 fatal wildlife strike incidents resulted in the deaths of 26 people. In terms of the U.S. military experience, the Air Force reported over 69,000 strikes since 1995, 23 fatalities, 12 aircraft destroyed and over $400 million in damage. Around the world since 1988, bird/other wildlife strikes have resulted in 258 deaths and 245 aircraft destroyed. The European Space Agency has estimated that bird/ other wildlife strikes around the world cost airlines over $1 billion a year.

According to the FAA report, “The aircraft components most commonly reported as struck by birds from 1990–2014 were the nose/radome, windshield, wing/rotor, engine and fuselage.” Of strikes inflicting damage, the engines were affected most often and, as illustrated by the incidents previously described, represent the greatest risk for major accidents. As for terrestrial animals, the report says that “most commonly reported as damaged were the landing gear, wing/rotor, propeller and “other.” Terrestrial animals pose the greatest risk at smaller, GA airports where perimeter fencing is absent.

Approximately 6 percent of bird strikes caused a negative effect on flight, and that percentage grew to 21 percent for terrestrial animal strikes, the report said. This includes precautionary or emergency landings and rejected takeoffs. For the landing incidents, 48 of 5,217 events included jettisoning of fuel, an average of 14,136 gal (53,510 L) per incident.

Most bird strikes occur at lower altitudes. Over 70 percent of strikes occurred at or below 500 ft AGL. For commercial aircraft, the greatest threat occurs at and near airports when aircraft are taking off or are in the landing phase, including approach. For GA, any low-level flight carries a strike risk. Bird strikes decreased markedly with increases in altitude (about 34 percent for every 1,000 ft gain in altitude). However, there is no perfectly safe altitude or flight level. The U.S. record for the highest bird strike on a commercial aircraft is 31,300 feet AGL. The world record for the highest bird strike — 37,000 ft — was set Nov. 29, 1973, on a commercial flight over Abidjan, Ivory Coast. And although the number of damaging strikes has decreased below 1,500 ft AGL (likely due to preventative measures), the number of damaging strikes above this altitude has stayed the same.

The FAA report noted that 518 species of birds have been struck since 1990. Of these, 214 species have caused damage. Doves/ pigeons represent the most commonly struck birds (specifically, mourning doves lead the strike list). Larger bird species, especially waterfowl, gulls and raptors, are associated with the most damaging strikes. Waterfowl strikes comprised 29 percent of all damaging strikes. The Canada goose produced the most damaging strikes — 757 over the 25-year period. Not only are these bird larger than most, they also tend to fly in flocks.

Flocks of birds pose a greater risk because they increase the probability of a strike. Also, in terms of engine-ingestion effects,

The damaged fan blades of a Pratt & Whitney JT8D engine after a bird strike.

there is more biomass to potentially deal with. Even small birds, if there are enough of them, can cause engine problems and engine failure. Even one bird can bring disaster. On Sept. 28, 2012, a Sita Air Dornier 228-200 operating as Flight 601 crashed just after takeoff from Tribhuvan International Airport in Nepal, killing all 19 people on board. The airplane had struck a black kite, a raptor common in the region.

The FAA study showed that over half of bird strikes in the United States occurred in the four-month period from July through October, the end of nesting and beginning of fall migration. Nearly two-thirds of the bird strikes occurred during the day, when birds are most active. As to flight phases, landing is nearly twice as hazardous as takeoff.

From 1990–2014, 3.1 percent of all reported wildlife strikes involved animals other than birds. Strikes of bats accounted for 0.9 percent of all reported strikes, but these small flying mammals do little damage. Of the 3,360 reported strikes of terrestrial animals, 1,055, or 31 percent, damaged the aircraft, with 12 percent causing damage classified as "substantial" or greater and 30 aircraft listed as destroyed. Of the animals hit, there were 41 species of terrestrial mammals, 21 species of bats and 17 species of reptiles. In Alaska, aircraft have hit moose and caribou. Alligators and snapping turtles have been encountered on some Florida runways. Pronghorn antelope have been hit in Arizona. Planes have struck Texas armadillos. Terrestrial mammals are more likely to be encountered at night, in the fall, and during the approach and landing phases of flight.

Deer (predominantly white-tail deer) are the most common problem, accounting for one-third of all terrestrial animal strikes. Estimates of the deer population in the United States range from 15 million to 30 million. With an animal the size of a deer, contact almost always produces damage. In fact, of the 1,094 strikes involving deer from 1990–2014, 922 strikes, or 84 percent, caused damage (87 percent of all damaging terrestrial animal strikes) with a cost of $45.5 million. Twenty-four aircraft were destroyed, and there was one fatality.

Another animal that has adapted to human habitation is the coyote. Despite a never-ending attempt to limit the harm this species poses, the coyote has flourished and is found in every state except Hawaii. In the past 25 years, there have been 469 strikes involving coyotes, including 42 with damage totaling $3.8 million.

Even something as innocuous as a rabbit can cause problems. Eastern cottontails were struck 73 times over the past 25 years. Four incidents had an effect on flight, and three resulted in damage to aircraft totaling $96,000. Domestic animals also have been struck by aircraft. The first recorded terrestrial wildlife strike involved a dog on July 25, 1909. Before Louis Blériot became the first person to fly a plane across the English Channel, a farm dog ran into the propeller blades of his Blériot XI aircraft while the engine was warming up.

Although nonfatal strikes don't garner headlines, U.S. wildlife strikes that have a negative effect on flight — or actually do damage — occur every day.

Edward Brotak, Ph.D., retired in 2007 after 25 years as a professor and program director in the Department of Atmospheric Sciences at the University of North Carolina, Asheville.

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The Rise of the Drone: Friend or Foe?

by Christopher Smith, Holman Fenwick Willan LLP

The practical application of lightweight drones or to give them their proper classification, small unmanned aircraft (SUA), has widened greatly in recent years. Use of SUA are no longer the sole domain of film production companies or military institutions, rather they are now seen as recreational toys and already commonplace in the construction and oil and gas exploration industry. Amongst the more visionary, SUA are also a vehicle for delivering small packages. However, there is a direct correlation between the growth in use of SUAs and concern over the risks posed to more traditional airspace users and, in particular, the commercial aviation industry.

A cursory review of mainstream media is sufficient to dispel any suggestion that this revolution is science fiction and some champions of SUAs, such as Amazon, Facebook and Google, envisage them being used to facilitate internet access and to become as commonplace as mail delivery trucks on the road. However, the prospect of the UK skies being besieged with SUAs will sit uncomfortably with some. For example, on 20 April 2015, flights were disrupted at Manchester Airport when an SUA was reported to be flying in close proximity to the flight path of a commercial aircraft. This incursion is one of many examples of drones flying in close proximity to commercial aircraft. So, who will police the operation of an increasing number of SUA operators and what steps are already in place to ensure our skies are safe and stop a growing number of SUAs from becoming a public nuisance?

Despite the use of SUAs being in their infancy, particularly in a commercial context, there is already a relatively detailed framework within which operators are required to work. Whilst relatively few details have been published as to the specifications of Amazon's SUA or other commercial SUAs, most comparable SUAs typically weigh less than 20 kilos. As such, they are not subject to regulatory oversight from a single body on a pan-European basis. Rather, operators must conform to the rules set out in each particular jurisdiction within which they wish to operate. In the UK, this means deferring to the UK Civil Aviation Authority (CAA). Whilst there are minor nuances to the rules, broadly speaking, a person wishing to operate an SUA, weighing 20 kilos or less, for commercial purposes, may only do so with the permission of the CAA. Whilst, there is no requirement to demonstrate that the SUA is airworthy (as with the vast majority of manned aircraft), applicants will need to demonstrate that they have considered the safety implications and taken necessary steps to ensure that the SUA will not endanger any person or property.

Central to the approval process will be a need to demonstrate the SUA can avoid collisions with other aircraft and objects. For flights out to a maximum of 500 metres horizontally and 400 feet vertically from the operator, it is accepted that collisions can be avoided by observation. Beyond these parameters, the SUA will need to fly within segregated airspace (a block of airspace specifically allocated for an SUA on a particular flight) or be fitted with 'Sense-and-Avoid' technology. This technology has the capability to see, sense or detect conflicting traffic and take the appropriate action. The CAA have stated that it is currently not aware of any Sense-and-Avoid system with adequate performance and reliability, but that several areas of segregated airspace have already been established for testing purposes.

Even when a standard permission has been granted by the CAA, commercial operators are still prevented from flying directly overhead persons, vehicles and residential areas. Without modification, this rule may prove problematic for Amazon in its quest to make doorstep deliveries. In addition, SUA operators are not permitted to fly drones within controlled airspace, which would exclude most of the City of London, Isle of Dogs and Westminster from any commercial use of SUAs.

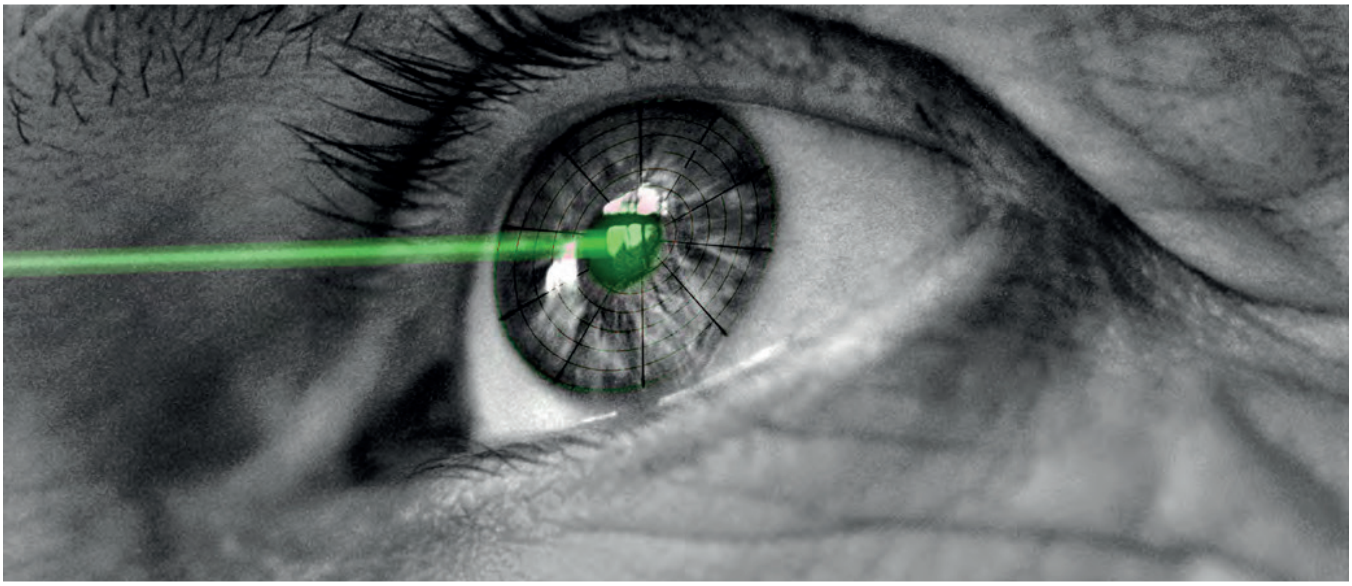
Current legislation does not require operators of SUAs under 20 kilos to maintain any third party liability insurance. However, given that the current applicable legal regime operates on a strict liability basis, a prudent operator may well seek insurance cover irrespective of the statutory exemption. An operator of an SUA will be liable for any material loss or damage caused to persons or property, on the ground, irrespective of whether the operator or pilot has been negligent. However, a member of the public will have no right of action (for trespass or nuisance) solely because an SUA has flown over their property (at a reasonable height), unless the SUA has been flown dangerously. Any damage sustained in the air will fall outside the afore-mentioned regime. Such claims would be based on normal principles of negligence, attracting an unlimited liability.

In addition to the above civil liabilities, persons not adhering to the rules of the air, could find themselves on the wrong end of enforcement action from the CAA and subject to a fine and/or imprisonment. However, all reports of close encounters with commercial aircraft are thought to involve recreational users (which sit outside the above CAA framework) and perhaps it is these users that are the cause of most concern. No prior training, registration or insurance is required and unless a recreational user seeks out further information on airspace regulation, such user is free to take to the skies with little or no knowledge of the applicable rules. That said, arguably, avoiding flying in close proximity to manned aircraft is a matter of common sense. Nevertheless, the increased frequency of airspace incursion would suggest otherwise. The latest 'drone code' from the CAA appears to do little to address this problem as it is dependant on users seeking out the information.

Whilst Amazon and other commercial operators appear firmly committed to revolutionising the commercial application of SUAs, there appears to be some way to go to overcome both the technological and practical obstacles that the current regulatory regime imposes. However, the risk profile of operating SUAs on a commercial basis is not insignificant and careful consideration needs to be given to navigating through the compliance regime and managing the liability risks. Of greater concern is the use by recreational users. The absence of regulation, coupled with the difficulties in identifying pilots of these remote vehicles via a comprehensive framework of registration makes the problem a difficult one to resolve. Absent a wholesale ban on non-commercial use, it should be incumbent upon SUA manufacturers to ensure that adequate information is included at the point of sale to ensure that recreational users are aware of the rules surrounding the use of SUAs in each jurisdiction.

Laser Danger

BALPA Flight Safety Specialist, Steve Landells, offers some guidance on what to do in the event of a laser attack



Laser illumination of aircraft continues to be a significant threat to aviation. BALPA is working with a number of agencies (including the CAA, the UK Flight Safety Committee and police) to address this issue but we are still seeing incidents in the UK involving lasers being directed at aircraft, both fixedwing and rotary, during all phases of flight. Laser illumination of an aircraft will inevitably startle and dazzle the pilots and may result in significant pilot distraction. There is now a widely held concern that a laser illumination event may result in a serious injury being sustained by a pilot during flight, with the associated erosion of flight safety margins.

The rapid proliferation of visible laser beams in airspace has resulted in a multitude of documented cases of flight crew laser illuminations since the early 1990s. Worldwide, various ALPAs (Airline Pilots Associations) have for many years aggressively urged the authorities to address the laser problem, but it has proven a difficult problem to thwart. To date only a handful of perpetrators of a laser incidents have been prosecuted and convicted of this crime. Despite continuing law enforcement efforts to deter and apprehend miscreants there were 1,440 reported laser strikes on aircraft in the UK and over 3,800 in the US in 2014 alone.

Using lasers or other lights against an aircraft creates a summary offence under two Air Navigation Order (ANO) articles:

- ANO Article 222: *A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft.* If the distraction or dazzle is serious, the person may be guilty of an offence of reckless endangerment under:
- ANO Article 137: *A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.*

The courts have the option of punishing this latter crime with a prison term.

In February 2013, the US Federal Aviation Administration (FAA) issued Advisory Circular (AC) No. 70-2A (which replaced 70-2 from 2005), 'Reporting of Laser Illumination of Aircraft' in response to a significant increase in the numbers of unauthorised illumination of aircraft by lasers. That AC requires all pilots to immediately report any laser sightings to air traffic controllers. It then requires controllers to share that information through the federal DEN – Domestic Events Network (a phone line that is constantly monitored by safety, security and law enforcement personnel). Air traffic controllers will then work with the police to identify the source of the lasers to ensure a rapid police response to the scene. One of the most significant changes from the 2005 circular was the addition of the following paragraph:

FAA and other governmental studies show the exposure of aircrews to laser illumination may cause hazardous effects (e.g. distraction, glare, afterimage, flash blindness, and, in extreme circumstances, persistent or permanent visual impairment), which could compromise safety by adversely interfering with the ability of aircrews to carry out their responsibilities. ATC regards a laser illumination incident as an in-flight emergency, and will treat them as such, until the aircrew states otherwise.

How a laser event may affect pilots

A laser illumination event can result in temporary vision loss associated with:

- Flash blindness – a visual interference that persists after the source of illumination has been removed
- After-image – a transient image left in the visual field after exposure to a bright light
- Glare – obscuration of an object in a person's field of vision due to a bright light source located near the same line of sight.

Laser effects on pilots occur in four stages of increasing seriousness:

1. Startle and distraction
2. Disruption to visual field (dazzle)
3. Disorientation
4. Incapacitation

Given the many incidents of cockpit illuminations by lasers, the potential for an accident definitely exists but the fact that there have been no laser-related accidents to date (October 2015) indicates that the hazard associated with current lasers can be successfully managed. As the power increases so does the concern surrounding potential outcomes. Technologies are available to mitigate the effects of lasers, but are still immature, do not provide fullspectrum protection and are unlikely to be installed on airline flight decks in the foreseeable future.

Advice to pilots experiencing a laser illumination event [NB1]

- **Shield the eyes from the light source with a hand or a handheld object and avoid looking directly into the beam. It is possible that a laser successfully aimed at the flight deck will be presaged by unsuccessful attempts to do so; these will be seen as extremely bright flashes coming from the ground and/or visible in the sky near the aircraft. Treat these flashes as a warning you are about to be targeted and prepare to shield the eyes. Do not look in the direction of any suspicious light.**

- Alert the other crew member(s) using the phrase 'Laser Attack' (initially assume you have been deliberately targeted and anticipate further illuminations) and determine whether they have suffered any laser-related effects. If the other front seat pilot has not been affected, he or she should immediately assume or maintain control of the aircraft.

- **Avoid rubbing eyes, to reduce the potential for corneal abrasion.**

- Manoeuvre to block the laser, if possible, and subject to ATC coordination. If on approach, consider a go-around.[NB2]

- **Engage the autopilot.**

- After regaining vision, check flight instruments for proper flight status.

- **Turn flight deck lighting to maximum brightness to minimise any further illumination effects.**

- Immediately report the laser strike to ATC, including the direction and location of the laser source, beam colour and length of exposure (flash, pulsed and/or perceived intentional tracking). Do not look directly into the beam to locate the source. CONSIDER DECLARING AN EMERGENCY.

- **As soon as flight safety allows, check for dark/disturbed areas in vision, one eye at a time.**

- If incapacitated, contact ATC for priority/emergency handling. Consider using autoland.

- **If symptoms persist, obtain an eye examination as soon as practicable.**[NB4]

- File an MOR. Reporting of laser strikes (and indeed interference from any high-powered light) is mandatory under both the ANO and EU Regulations. In the UK, ATC will notify the police. When possible, write down all details for the police. Give serious consideration as to how the flight was affected.[NB3]

- **If the normal procedures of a flight have been disrupted, especially if a handover of control has been required, then do not refrain from declaring that there was 'endangerment' of flight upon a laser strike. This will allow perpetrators to be prosecuted under Article 137, as opposed to solely Article 222. This will give the courts the option to impose significant punishments that will, hopefully, attract media attention and act as a deterrent to others.**

- If rostered for further flight sectors, consider whether you are physically and psychologically still fit to fly even if your self-assessment indicates no visual impairment. It is for individual flight crew to determine their fitness to fly in such circumstances, regardless of operator policy.

Laser classes

The British Standard sets out seven classes of laser, with the highest class indicating the greatest radiation hazard posed by the laser.

This classification system uses not only power but also the concept of an Accessible Emission Limit (AEL) which is the maximum value of accessible laser radiation that an individual could be exposed to.

Class 1: Exposure to a Class 1 laser will not result in eye injury. Examples of uses include CD players and laser printers.

Class 1M: Highly divergent or large diameter beam so only a small part of the laser beam can enter the eye at any one time. These can be found in fibreoptic communication systems.

Class 2: These have a maximum power output of 1 milliwatt (or one-thousandth of a watt) and have a wavelength of between 400 and 700nm. The natural reaction of blinking should protect an individual from injury. Barcode scanners and some laser pointers fall into this category.

Class 2M: Again, a larger diameter or highly divergent beam that means only a small part of it can enter the eye. These can, however, be harmful if viewed using magnifying optical instruments.

Class 3R: Maximum output of 5mW which can potentially cause eye injury. May be found in some laser pointers and DIY alignment tools.

Class 3B: The first category that is not suitable for general use by consumers. These have an output power of up to 500mW (half a watt) and could cause eye injury both from direct beam and in some cases reflections. Many research lasers fall into this category.

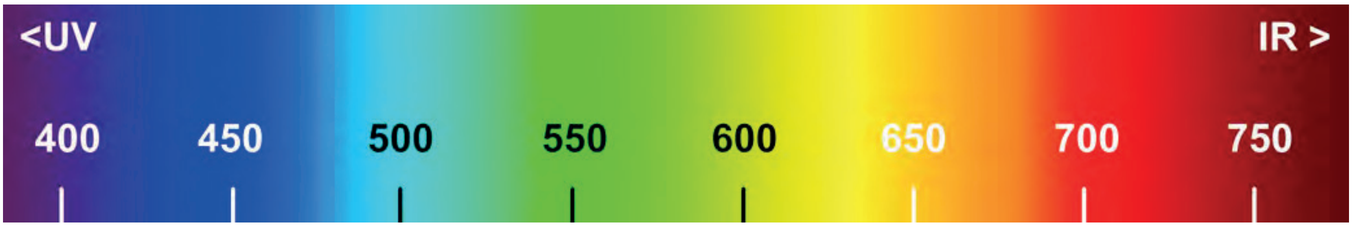
Class 4: These are in excess of 500mW and there is no upper restriction. These are capable of causing injury to both the eye and the skin and will also present a fire hazard. These have many applications ranging from laser displays to cutting metal.

Divergence

It is not just the power of a laser that will dictate how it behaves; the collimation plays a significant role as well. Collimated light is light whose rays are parallel and show little divergence over distance; light from a laser is therefore highly collimated. When looking at the safety implications of a laser beam one important parameter to consider is the amount of power in the beam divided by the cross-sectional area of the beam. This parameter is referred to as the irradiance of the beam and is measured in watts per square metre or Wm-2.

Wavelength

The wavelength of a light source will dictate what colour is perceived, and this is measured in nanometres, or one-thousand-millionth of a metre and is abbreviated to nm. The visible spectrum ranges from approximately 400nm to 780nm but the response of the human eye peaks at around 550nm so if a green light (532nm) is compared to a red light (670nm) of equal radiant power then the green light will be perceived to be approximately 30 times brighter than the red one.



Footnotes:

NB1: Your company advice always remains the primary source of reference.

NB2: If warned in advance by ATC or other aircraft of laser activity, consider requesting a different runway, holding until it is resolved, or diverting.

NB3: It is important to include in any report details of how the flight was disrupted. Include details of any distraction and visual interference (however short in duration) experienced, and details of any checklists interrupted. If the flight profile was changed or energy management affected then this needs to be included. Any of the above may indicate the possible endangerment of the aircraft and should be reported as such.

NB4: As mentioned above, laser illumination can result in transient visual impairment, such as a retinal after-image remaining visible and/or camera flash-type blindness. Usually, these symptoms subside after a period of time, provided the individual does not look at the beam. As the power and availability of lasers increases it may be possible that a laser illumination event will result in longer term, or even permanent eye damage. If any visual symptoms persist after landing, then obtain an ophthalmologic examination. Do not use pain as an indicator of retinal damage; there are no painsensitive nerves in the back of the eye so pain will not necessarily be present. Advise the specialist that the evaluation should include ophthalmoscopy, visual acuity testing and central visual field testing with the Amsler grid. After this evaluation, consult your employer's Aeromedical Department, your AME and/or the CAA Medical Department before returning to duty. If the visual effects remain, do not drive or fly as crew. The CAA has produced an Aviation Laser Exposure Self-Assessment (ALESA) tool which pilots can access online; download and save it, with instructions, for their flight bags, or print a hard copy at the correct size in advance for use following a laser strike.

It can be found at: www.caa.co.uk/docs

A BALPA member is undertaking a study into the reporting of laser strikes. If you would be willing to share your experiences with him and/or take part in a short, online survey please contact him at balbir.chopra@city.ac.uk.

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Lithium batteries: safe to fly?

Today, Lithium batteries play a barely visible, yet essential role in both our daily life and aviation alike. Manufactured and handled correctly, Lithium batteries are safe. But production failures, mishandling, or not being aware of their specific characteristics can have serious repercussions.

Lithium batteries are today's power source of choice. As we become ever more reliant on Portable Electronic Devices (PEDs) to provide at your fingertips information, entertainment and communication, then so increases the demand for more powerful, yet lighter, sources of power.

Hundreds of millions of Lithium batteries or equipment with Lithium batteries are carried on aircraft annually. These can be as part of passengers carry-on items, as aircraft (e.g. Portable IFE, defibrillators) or aircrew equipment (such as Electronic Flight Bags). They can be shipped as cargo in battery form or within other purchased items to support the demand for "just in time deliveries", or indeed as power supply for aircraft equipment. Lithium batteries are becoming continually more common place in the aircraft environment.

But the introduction of Lithium batteries included some highly visible cases of cell phones or laptops self-igniting and burning. Likewise, several events have occurred on aircraft, ranging from localized and limited fires to large, uncontrolled in-flight fires resulting in hull losses and fatalities.

The air industry has become more aware of the specific characteristics of Lithium batteries and the associated risks can now be mitigated. Procedures have been developed to address the risks for Lithium batteries being part of the aircraft design, those belonging to passengers or crews carry-on items, or indeed procedures linked to the shipping of Lithium batteries as cargo.

Lithium batteries: A Powerful and versatile technology, associated with a common risk

Lithium is the metal with the lowest density, but with the greatest electrochemical potential and energy-to-weight ratio, meaning that is has excellent energy storage capacity. These large energy density and low weight characteristics make it an ideal material to act as a power source for any application where weight is an issue, aircraft applications being a natural candidate.

While the technology used and the intrinsic risk is the same for all applications, different solutions and procedures exist to mitigate this common risk depending on where and how the Lithium battery is used (i.e. part of the aircraft design, transported as cargo or in passengers and crews luggage and PED).

This section will highlight the benefits of this new technology irrespective of its use in applications, and describe the associated risk of "thermal runaway".

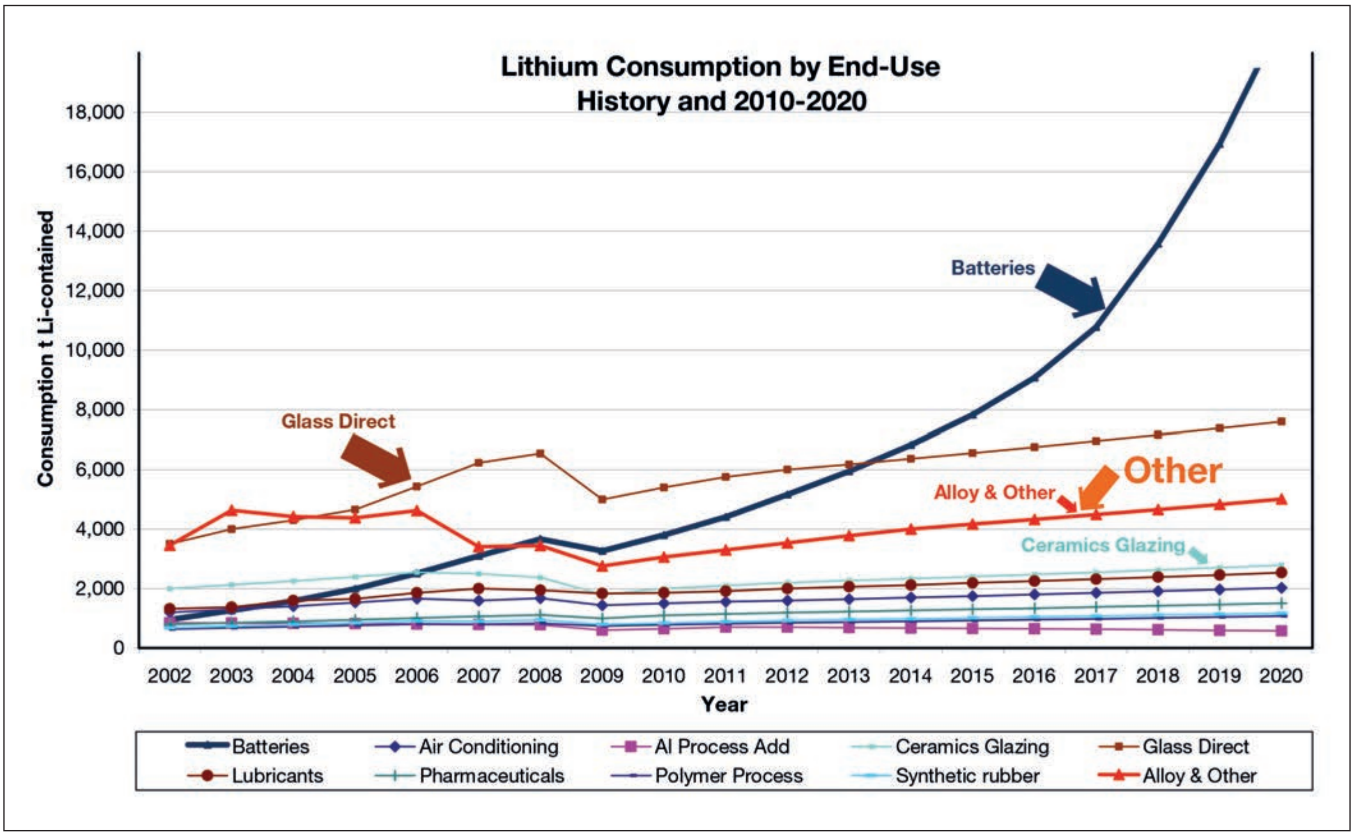
Lithium: an increasing use

Experimentation with Lithium batteries began in 1912 and the first Lithium batteries were sold in the 1970's. In the nineties, Lithium battery technology began to be widely used by a number of industries that were looking for light, powerful and durable batteries.

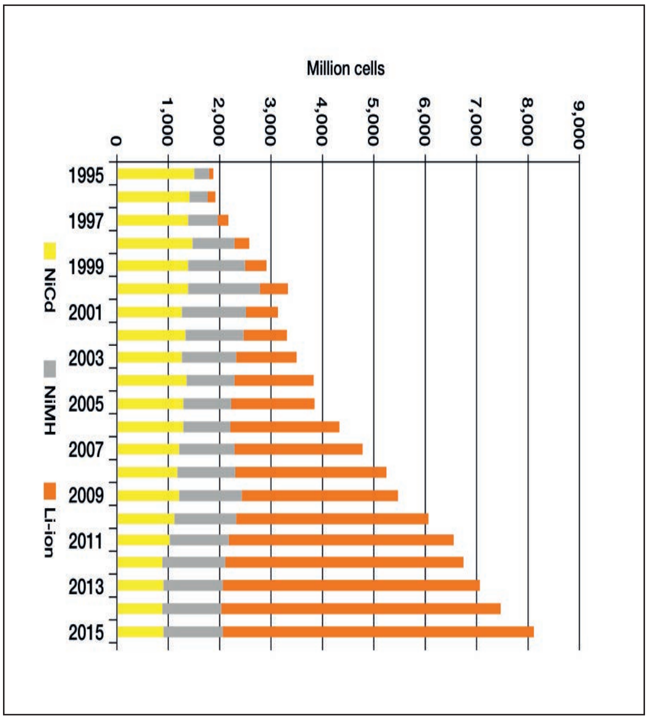
As it turns out, Lithium use in batteries has been one of the major drivers of Lithium demand since the rechargeable Lithium-ion battery was invented in the early nineties **(fig.1).**

Today, Lithium batteries are progressively replacing previous technology batteries – e.g. Nickel-Cadmium, Lead-acid – and can be found in most of electronic and autonomous electric systems or equipment. Development and applications are evolving with latest uses including ultrathin (down to 0.5 mm) and flexible technologies.

The Lithium battery market is extremely dynamic and expanding fast, with a growing application as the power source for a wide range of electric vehicles. In fact, no level off is foreseen in the coming years. In 2014, 5.5 billion Lithium-ion batteries were produced **(fig.2)**.



(fig.1) *Forecast Lithium demand by application (Source: TRU Group)*



(fig.2) *Worldwide batteries production (Source: Christophe PILLOT, Avicenne Energy)*

Different types of Lithium batteries, different applications

Different types

Lithium batteries can take many forms. They can be as tiny as single cell button batteries – for example used as power supply for watches – or multi cells (usually rechargeable) batteries that can act as high power energy sources for electric vehicles, or indeed as back-up power supply on-board aircraft **(fig.3).**

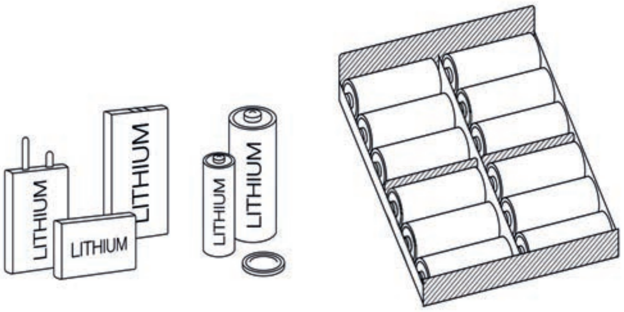
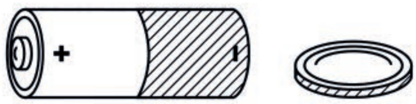


fig.3) *Types of Lithium batteries: single / multi cells*

Different technologies
The term "Lithium battery" actually refers to a family of batteries that can be divided into two categories:

- **Primary: Lithium-metal, non-rechargeable batteries**
  These include coin or cylindrical batteries used in calculators, digital cameras and emergency (back-up) applications for example **(fig.4)**.

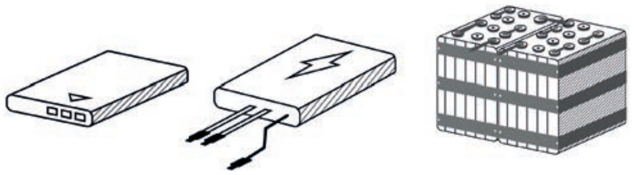
  Lithium-metal batteries have a higher specific energy compared to all other batteries, as well as low weight and a long shelf and operating life.



(fig.4) Lithium-metal batteries

- **Secondary: Lithium-ion/Lithium-polymer rechargeable batteries**
  Key current applications for this type of batteries are in powering cell phones, laptops or other hand held electronic devices, as well as electric/hybrid cars and power stores **(fig.5).**

  The advantages of the Lithium-ion or Lithium-polymer battery are its ability to be recharged in addition to its higher energy density and lighter weight compared to nickel-cadmium and nickel-metal hybrid batteries.



(fig.5) Lithium-ion / Lithium-polymer batteries

One main intrinsic risk to tackle: the thermal runaway

As with every new technology, Lithium batteries offer a number of advantages, but they also come with limitations. Although previous batteries technologies were not risk-free, Lithium based batteries have a larger electrochemical potential; therefore if damaged, mishandled or poorly manufactured, they can suffer stability issues and be subject to what is called a "thermal runaway". This phenomenon is well recognized now, and it can be mitigated providing awareness and prevention actions are taken.

A self-ignited and highly propagative phenomenon
In case of internal degradation or damage, a battery cell rapidly releases its stored energy (potential and chemical) through a very energetic venting reaction, which in turn can generate smoke, flammable gas, heat (up to 600°C and 1000°C locally), fire, explosion, or a spray of flammable electrolyte. The amount of energy released is directly related to the electrochemical energy stored and the type of battery (chemic and design).

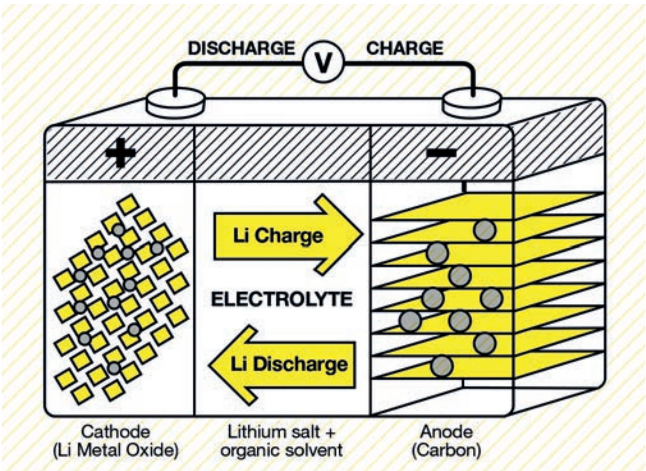
Both the primary and secondary types of batteries are capable of self-ignition and thermal runaway. And once this process is initiated, it easily can propagate because it generates sufficient heat to induce adjacent batteries into the same thermal runaway state.

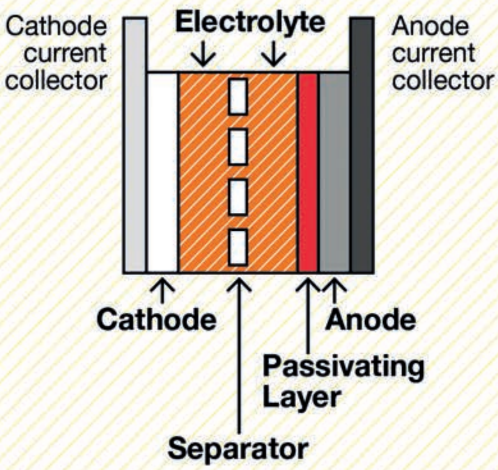
Lithium batteries can be both a source of fire through self-ignition and thermal runaway, and a cause of fire by igniting surrounding flammable material.

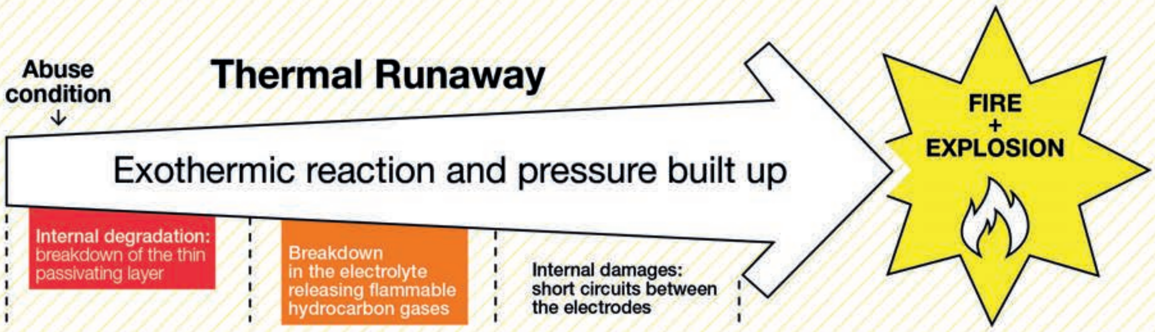
Insight into the thermal runaway phenomenon

A thermal runaway consists in an uncontrolled energy release. It refers to a situation where an increase in temperature changes the conditions in a way that causes a further increase in temperature, often leading to a destructive result.

In multi-cell batteries, the thermal runaway can then propagate to the remaining cells, potentially resulting in meltdown of the cell or a build-up of internal battery pressure resulting in an explosion or uncontrolled fire of the battery.

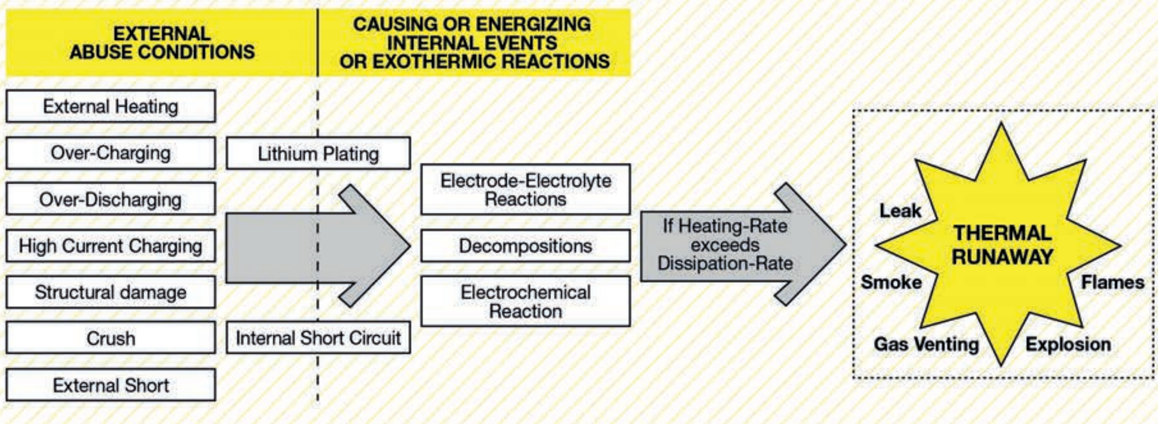


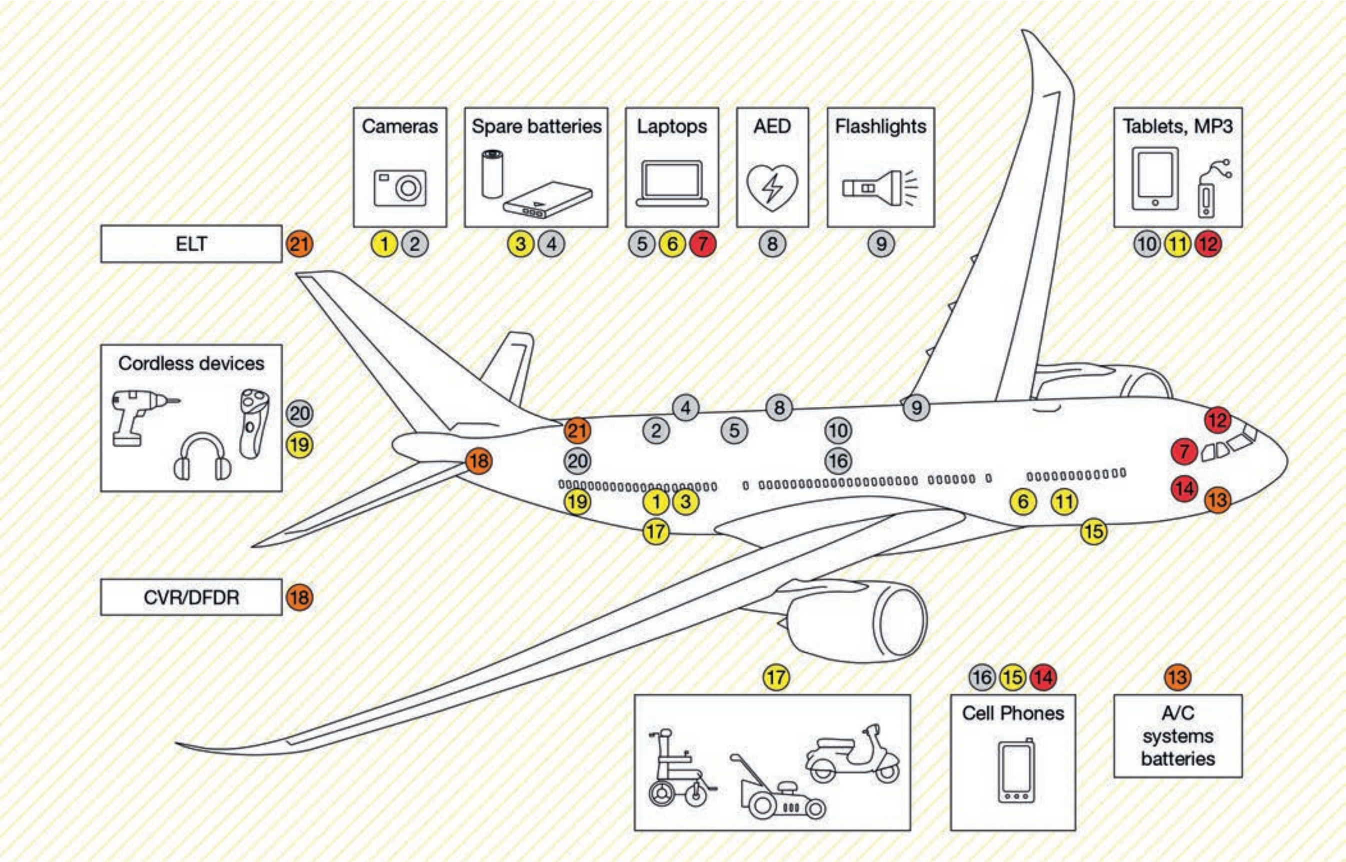




The main factors contributing to a thermal runaway are:

- Poor design or poor integration
- Poor cell or battery manufacturing quality
- Poor safety monitoring or protection
- Poor handling / storage / packing conditions





(fig.6) Lithium batteries on-board an aircraft

In-service experience

By their nature and properties, large numbers of Lithium batteries can be found in many places on-board an aircraft **(fig.6)**:

- In the cabin among the personal effects of crews and passengers
- In the cockpit as part of tablets used for flight data support
- In the cargo holds carried as cargo or in passengers baggage
- In the aircraft design.

Since March 20th, 1991, the FAA has recorded 158 incidents involving batteries carried as cargo or baggage according to their report on "Batteries & Battery-Power Devices – Aviation Cargo and Passenger Incidents Involving Smoke, Fire, Extreme Heat or Explosion" dated 30 June 2015. 81 of these events related to Lithium batteries.

The phenomenon of thermal runaway in an aircraft environment can be catastrophic. At the least it can range from limited degradation of personal equipment, or minor damage to the overhead storage compartment. In the case worst situation, thermal runaway in high density package of Lithium batteries can result - and has been implicated - in hull losses **(fig.7)**.

(fig.7) Consequences of Lithium batteries thermal runaway

Top Left: Damage to cabin overhead compartment video camera

Top Right: Hull loss

Left: Battery fire

FAA tests show that even a small number of overheating batteries emit gases that can cause explosions and fires that cannot be prevented by traditional fire suppression systems. In view of the possible consequences, Lithium batteries are classified as hazardous materials, therefore particular care and consideration must be taken to ensure safe operations in relation to use and transport of Lithium batteries (or devices containing Lithium batteries) when in an aircraft environment.

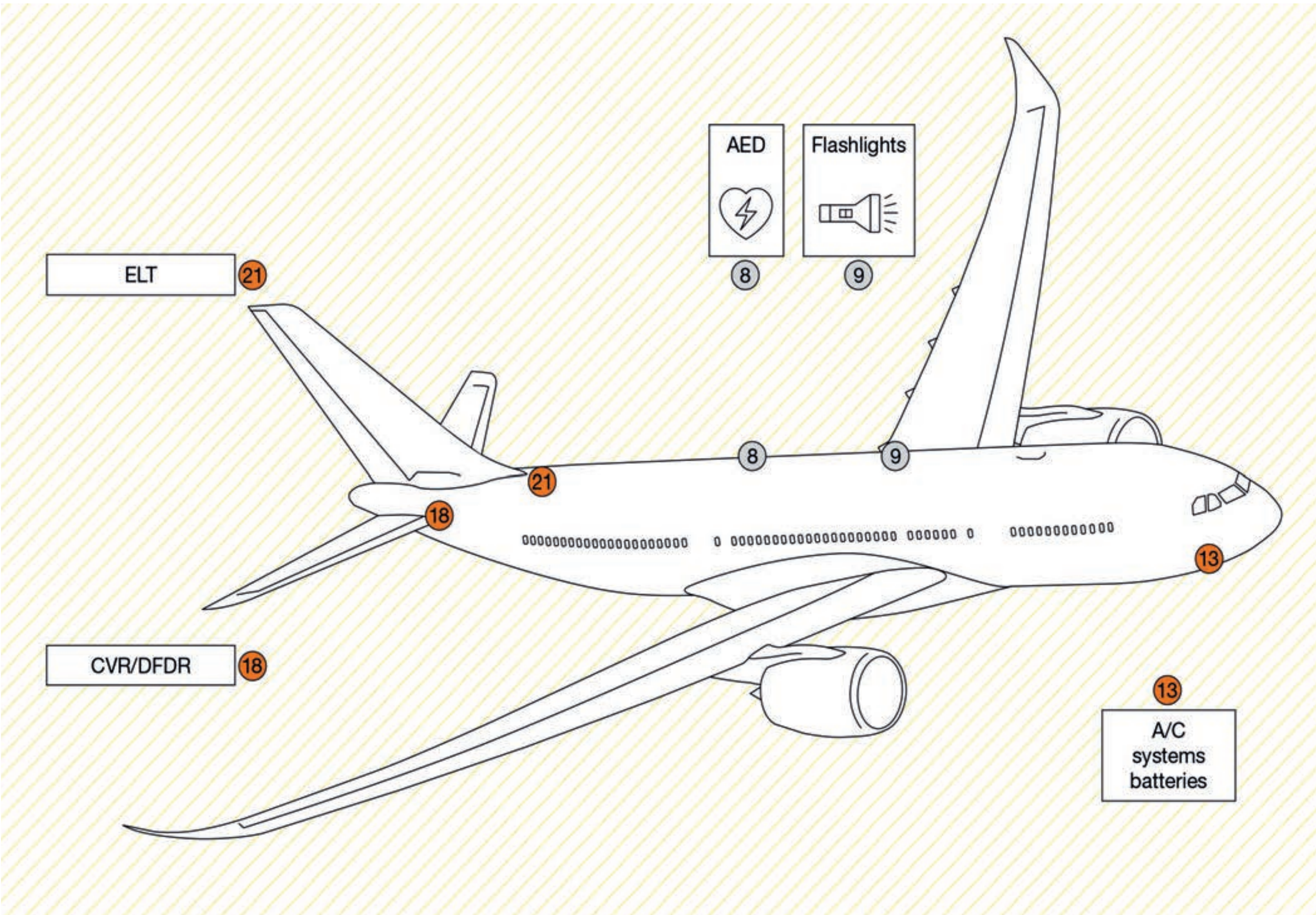
How to mitigate the risks posed by lithium batteries

Although investigation into reported events highlighted that some Lithium batteries fires were due to internal short circuits relating to design, manufacturing or integration shortcomings, many – if not most – fires were caused by abuse by the user. This may be deliberate or negligent abuse or physical damage due to mishandling, but quite often it is unconscious abuse.

Also, while strict regulations for transporting Lithium batteries as cargo exist, several incidents have been related to Lithium batteries being in the cabin. For this reason, a good awareness on risks posed by Lithium batteries of both airlines personnel and their passengers is crucial.

Permanently installed batteries

Mitigating the risks posed by Lithium batteries and preventing a thermal runaway or a fire starts with securing the batteries that form part of the aircraft design. In this respect, the Lithium batteries embedded in the aircraft design are subject to strict development and integration requirements, complying with the highest safety standards. The intrinsic risk of this new generation of Lithium based batteries is acknowledged at all levels of the aircraft design phase, as early as from the inception of the product and its systems. It is then mitigated thanks to acceptability justification based on each battery location, and a thorough review of installation, ensuring that no heat source and hazardous material or fluids are in the vicinity.



During an aircraft's service life, this risk can be mitigated by adhering to common sense precautions, such as using only the Original Equipment Manufacturer (OEM) parts. The use of counterfeit or non-authorized parts increases the risk of fire and explosion. Consequently, complying with the Airbus Parts Catalogue and exclusively using Airbus or OEM catalogue references for spare batteries is key.

Similarly, before installing spare batteries in Buyer Furnished Equipment (BFE) or in aircraft, operators should ensure the parts are genuine spare parts, that they have been stored and handled appropriately and present no mark of overheat or damage.

? DID YOU KNOW?

More information about the consequences on use of non-approved batteries can be found in OIT 999.0032/03 Rev 01, OIT 999.0035/04 and OIT 999.0145/14.

Carriage of Lithium batteries as air cargo

Increased usage of Lithium batteries as the power supply of choice has, not surprisingly, led to an increase in the shipping of Lithium batteries as air cargo. Today, one of the main risks posed by Lithium batteries is related to the shipping as freight.

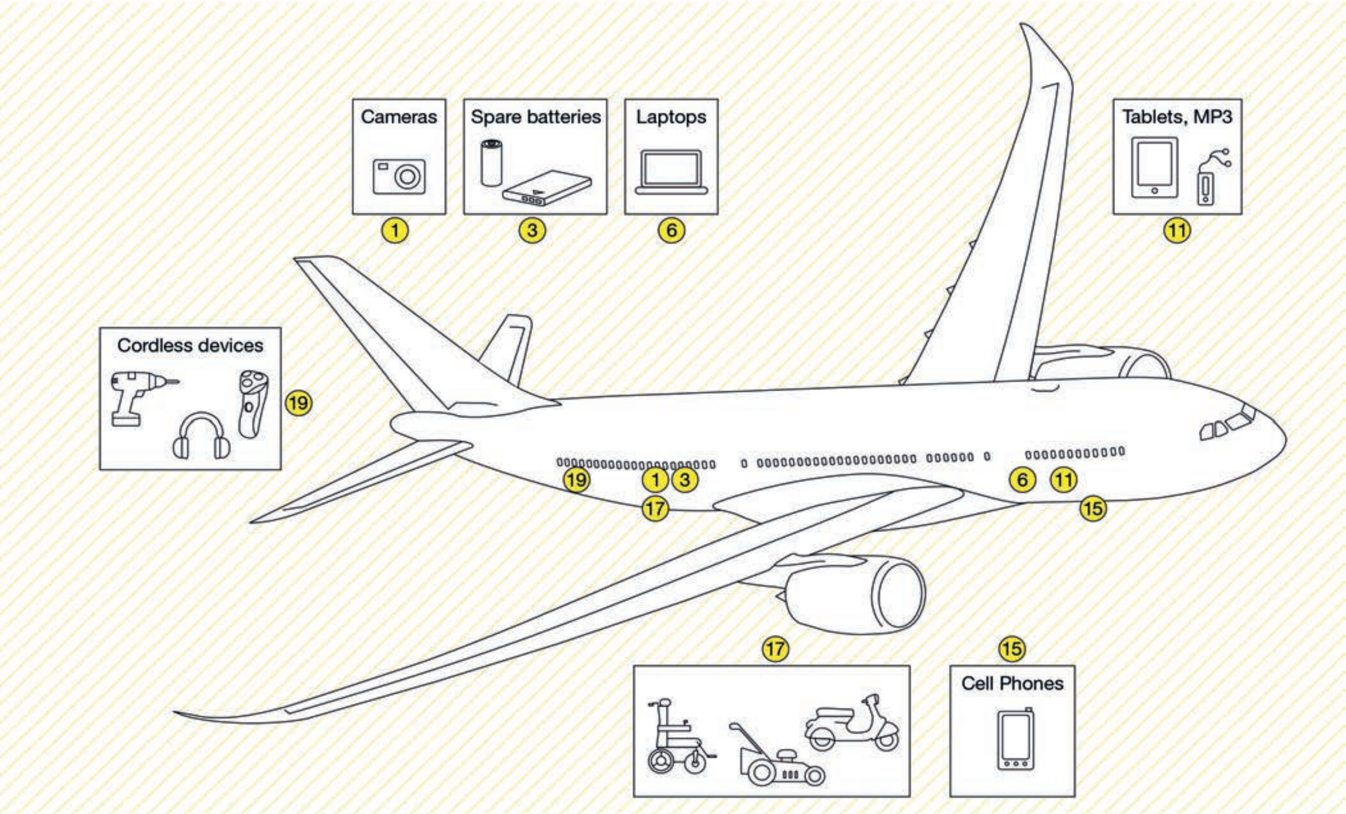
The existing ICAO regulations do not regulate the quantity of Lithium batteries that can be shipped as cargo on any single aircraft as a cargo load. The only limitations are associated to what can be loaded into each individual package. It is also worth understanding that these same regulations are not intended to control or contain a fire within that packaging.

What protection can the existing cargo compartment fire protection provide in the event of a Lithium battery fire?

Today's cargo fire protection of an aircraft is addressed by:

- Passive protection (cargo hold linings or protection of essential systems)
- Detection
- Suppression (use of Halon) or oxygen starvation
- Preventing hazardous smoke / extinguishing agents into occupied compartments.

Investigations have shown that the cargo compartment fire protection standards described in CS/FAR25 are not sufficient to protect the aircraft from fires involving high density shipments of Lithium batteries.



“High density” describes a quantity of Lithium batteries that has the potential to overwhelm the cargo compartment fire protection system. In fact, the impact of different characteristics of the batteries (e.g. chemistry, state of charge, size), cargo compartments types and loading configurations make it very difficult to define a quantity limitation that could be recommended at aircraft level, for all operational situations. Tests have demonstrated that some configurations, involving only one item of the regulated packaging size, has the potential to lead to significant damage of an aircraft.

Irrespective of the size of the shipment, research into the impact of both Lithium-metal and Lithium-ion batteries fire has demonstrated that the existing cargo compartment fire suppression systems – namely Halon 1301 (class C) or oxygen starvation (class E) – are unable to stop a thermal runaway and prevent propagation to adjacent cells. If a thermal runaway is initiated, heat and flammable gases coming from the degradation of the hydrocarbon electrolyte will be emitted. The existing fire protection cargo systems are not capable of containing these accumulated gases.

The passive protection standards are designed to withstand heat sources for up to 5 minutes and are not resistant against the characteristics of a Lithium battery fire. The temperature, duration and intensity of such a fire will quickly overwhelm the passive protections. In addition, the quantity and continuing production of smoke produced is likely to overwhelm the passive and active smoke barriers that protect the occupied compartments.

With these findings, the aviation industry came to the conclusion that today’s cargo compartments, which are certified to US CFR Part 25.857 and EASA CS 25.857, do not demonstrate resistance to a fire involving Lithium-metal and Lithium-ion batteries. For this reason, the inability to contain a Lithium battery fire for sufficient time to secure safe flight and landing of the aircraft, is an identified risk to the air transport industry.

Categorization of cargo compartments

Cargo compartments of the Airbus fleet are certified as class C and class E compartments according to CS 25.857. Additionally, some aircraft in service still have class D cargo compartments, but this classification was eliminated for new production in 1998.

- Class C compartments are required for passenger aircraft compartments not accessible during flight (lower deck) or if a fire could not be controlled from the entrance point, without entering the compartment. A class C compartment needs to be equipped with:
  - Smoke/fire detection system
  - Ventilation control
  - Built-in fire suppression system
  - Fire resistant linings (passive protection)
  - It needs to be demonstrated that no hazardous quantity of smoke, flames or fire extinguishing agents are able to enter occupied areas.

- Class D compartments need to be equipped with:
  - Ventilation control
  - Fire resistant linings (passive protection)
  - It needs to be demonstrated that no hazardous quantity of smoke or flames are able to enter occupied areas.

- Class E compartments are only allowed for freighter aircraft. They need to be equipped with:
  - Smoke/fire detection system
  - Ventilation control
  - Only critical systems need to be protected from fire
  - It needs to be demonstrated that no hazardous quantity of smoke, flames or noxious gases are able to enter occupied areas.

What the regulations say
In the light of the risks identified, in January 2015, the ICAO Dangerous Goods Panel took the position to ban the carriage of Lithium-metal batteries of all types, as cargo on passenger aircraft.

However, whilst this was an important development, Lithium-metal batteries only account for a small proportion of all Lithium batteries carried annually as air cargo. Consequently, research into the impact of a Lithium-ion batteries fire has continued. As already noted, this research has demonstrated that Lithium-ion batteries themselves represent a significant threat due to the fact that the existing cargo

compartment fire suppression functions are ineffective against a Lithium-ion battery fire.

As a result, regulatory authorities are now heading towards a larger ban on Lithium battery shipments as cargo on passenger planes that would include non-rechargeable and rechargeable batteries alike. At time of publication of this article, these discussions are on-going. At their last meeting in October 2015, the ICAO Dangerous Goods Panel (DGP) proposed a 30% State of Charge (SoC) limit as an interim measure aiming to reduce the risk of fire propagation to adjacent batteries and thereby improve aviation safety.

At the same time, discussions in ICAO are focussing on establishing appropriate packaging and shipping requirements to ensure safer shipment of Lithium-ion batteries. Airbus is also involved in the Civil Aviation Safety Team (CAST) investigating overall approaches from the battery itself to a combination of packaging / container and the aircraft itself.

The importance of correct transport and shipping of Lithium batteries therefore becomes key, and the involvement of the shipper and operator is crucial.

What shippers and operators can do: risk assessment and best practices

1. Check the latest industry available information and guidance

Air transport of Lithium batteries is controlled by international and local regulations. If transporting Lithium batteries, operators need to first check the latest instructions for the safe transport of dangerous goods by air, be they provided through Airworthiness Authorities or local regulations, and/or the ICAO.

2. Perform a risk assessment

In the end, the responsibility for the safe carriage of dangerous goods (including Lithium batteries) lies with the shipper and operator. It is recommended that if carriage of dangerous goods is pursued, then a safety risk assessment of cargo operations should be performed to determine if battery shipments can be handled safely.

With respect to Lithium batteries, guidelines for the assessment should consider factors such as:

- The quantity and density of Lithium battery shipment
- The type of Lithium batteries to be shipped
- Who the supplier/shipper of Lithium batteries is and their quality control
- The identification and notifi cation of all shipments of Lithium batteries (also Section II Lithium batteries)
- Accepting only Lithium battery shipments that comply with applicable regulations (ICAO and/or local regulations)
- Overall capability of the aircraft and its systems
- Segregation possibilities of Lithium batteries from other flammable/ explosive dangerous goods.

3. Ensure safe packaging and shipping

Local and/or international regulations provide the applicable set of rules that need to be complied with when transporting Lithium batteries. Attention should be given to:

- Training and awareness of employees regarding:
  - The aircraft limitations against a Lithium battery fire and existing mitigation means.
  - Regulations, handling procedures, the dangers of mishandling, and methods to identify Lithium battery shipments.
- Packaging:
  - Clearly identify shipments of Lithium batteries by information on airway bills and other documents.
  - Make sure that the packaging is correctly labelled and identified as dangerous goods according to ICAO technical instructions.
  - Do not ship damaged packages.
- Cargo loading: segregate any Lithium battery shipments from other dangerous goods that present a fire hazard (flammable and explosive goods).

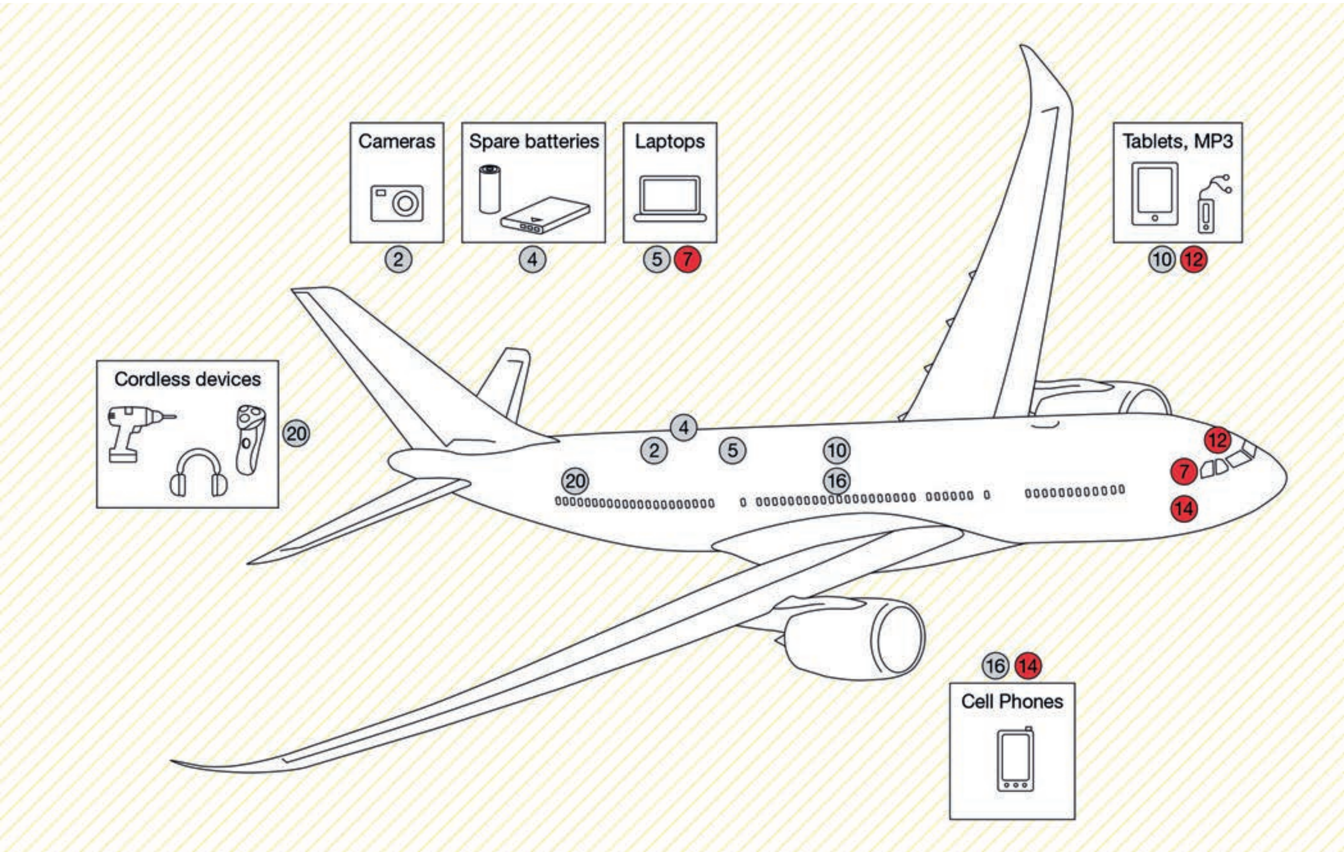
DID YOU KNOW?

More information on the carriage of Lithium-ion batteries is provided in Airbus ISI 00.00.00182 dated 24 July 2015. Industry Guidance, such as the IATA "Lithium Batteries Risk Mitigation Guidance for Operators" also provides useful information for mitigating the risk on the carriage of Lithium batteries.

Carriage of Lithium batteries in the cabin

Whilst recent discussions have shifted the focus towards the carriage of large quantities of Lithium batteries as cargo, due to their proliferation and use in many applications, operators need to also be aware of the risk of carrying Lithium batteries in passenger baggage – both checked in, off loaded cabin baggage and also carry-on cabin baggage.

The widespread use of Lithium batteries means that hundreds of Portable Electronic Devices (PED) are likely to be carried on a large aircraft, either in hold baggage or as carry on. Prevention is therefore essential to raise passengers' awareness of the risks associated to carrying Lithium batteries.



Raising passengers awareness before boarding

Recommendations have been developed with respect to what can or cannot be carried in passenger baggage. ICAO and IATA regulated and recommended general requirements with regards to carrying and managing what is carried in passenger baggage is that:

- Batteries carried should have been appropriately tested (e.g. should be manufactured by the original manufacturer).
- PEDs containing Lithium batteries should be carried in carry-on baggage.
- Spare batteries (i.e. those not contained in a PED), regardless of size, MUST be in carry-on baggage. They are forbidden in checked baggage and should be appropriately protected against short circuit, e.g. by leaving the batteries in its original retail packaging.
- Consider the quantity carried by individuals. Whilst there is no limit on the number of PEDs or spare batteries, below a specified size (normally 100 Watt-hour) that a passenger or crew member may carry, but they must be for personal use.

The key however is making both the customer facing representatives and the passenger themselves aware of the risks presented by the incorrect carriage of Lithium batteries, and making sure that they know the regulations. To increase the awareness to the travelling public, posters and Lithium battery pamphlets can be a useful option and are widely used by air carriers and authorities around the world alike. As an example, FAA have issued Safety Alerts for Operators (SAFO) number 15010, which deals with "Carriage of Spare Lithium Batteries in Carry-on and Checked Baggage".

Raising passengers awareness on-board

A key aspect to mitigating the risk is making the owner, namely the passenger, aware of the risks inherent to Lithium batteries being used in an aircraft environment. Make sure passengers are aware of what is allowed in the terms of Lithium batteries in carry-on baggage, and the requirement for correct storage, but also impact of a PED getting trapped in the movable seat mechanism.

Due to their small size, PEDs can easily be trapped in seat mechanisms. The subsequent crushing of PEDs during adjustment of the seat can lead to overheat and thermal runaway.

Making passengers aware of this inherent risk can help reduce this scenario. For example, including a note in the pre-flight briefing to ensure that in case a PED is lost, then the seat is not moved until the component is retrieved is an option. Likewise, making cabin and flight crew aware of this potential failure mode is key to quick and efficient action when addressing a fire caused by a PED.

Information

IATA has issued more information on the risk mitigations for operators on carriage of Lithium batteries. Visit their website (http://www.iata.org/whatwedo/cargo/dgr/Pages/lithium-batteries.aspx) for more information and guidance on different situations, making sure the last approved versions are used.

Mitigating the risks posed by Lithium batteries: summary

Lithium battery thermal runaways can be caused by design / manufacturing quality / integration shortcomings or by inadequate compliance with a number of basic rules. The following principles should be adhered to in order to minimize the risk of Lithium battery fires and explosions:

- Ensure that Lithium cells/batteries shipped comply to international standards.
- Ensure that loads conform with ICAO / IATA labelling, packaging and handling recommendations.
- Ensure compliance to the Airbus Parts Catalogue when replacing batteries.
- Ensure that ground, flight and cabin crews are trained and passengers are aware of Lithium batteries specificities.

How to manage the consequences of a lithium battery fire

As detailed previously, proactive action by making passengers and airline personnel aware of the risks posed by Lithium batteries is preferable than reacting to a fire caused by a Lithium battery. Therefore knowing what to do in the unlikely event of a Lithium battery fire is essential. The key principles to safely and efficiently tackling a Lithium battery fire, whether it is in the cabin of flight deck, being:

- Keep people away from the fire
- Minimize risks of fire propagation
- Apply specific firefighting principles.

Apply specific firefighting principles

Classical firefighting procedures and fire extinguishing means are not efficient to stop a lithium battery fire.

Halon can suppress open flames, but it is ineffective in addressing the source of fire. Use of water is the best option to allow cooling and limit the propagation to adjacent cells.

Fight the flames

Fight the heat

Once a lithium battery cell has ignited then the effort must concentrate on cooling the surrounding cells by use of water (or other non-alcoholic liquid) and preventing deterioration of the situation to avoid any fire propagation to the adjacent battery cells.

To this extent specific procedures that provide guidance on managing Lithium battery fires have recently been included for both cabin crew (in the CCOM) and flight crew (in the FCOM/QRH/FCTM).

Cabin crew procedures

Isolate the source of fire

Reacting to a Lithium battery fire in the cabin starts with isolating the source of fire. Indeed, a smoking battery may explode at any time, due to the highly exothermic thermal runaway.

In the cabin, do not try to pick up and attempt to move a burning device or a device that is emitting smoke.

Prevent propagation by ensuring that no flammable material (fluids, gas, devices) are near the smoking battery. Also relocate passengers away from the burning or heating device.

Fight the fire according to specific procedures

Once the burning / heating device has been isolated, the fire itself needs to be addressed. To this end, three specific cabin crew procedures to deal with Lithium batteries fires have been developed based on the FAA recommendations.

LITHIUM BATTERY FIRE

Ident.: 09-020-00015205.0001001 / 28 JAN 14
Criteria: LR
Applicable to: ALL

The roles of the firefighter, assistant firefighter and communicator must be distributed according to the basic firefighting procedure.

In the case of PED or spare lithium battery fire in the cabin or when notified by the flight crew:

- **If there are flames:**
  FIREFIGHTING EQUIPMENT.................................TAKE
  Consider the use of a PBE and fire gloves.
  HALON EXTINGUISHER.................................DISCHARGE
  Halon extinguisher must be discharged to suppress the flames prior to cool down the PED or the Spare lithium battery.
- **When the flames are suppressed or If there are no flames:**
  ON PED or spare lithium battery........................POUR WATER OR NON-ALCOHOLIC LIQUID
  The PED or Spare lithium batteries must be cooled down by pouring water or non-alcoholic Liquids
  STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE ....APPLY

WARNING	*- Do not attempt to pick up and move a smoking or burning device* *- Do not cover the device or use ice to cool down the device. Ice or other materials insulate the device increasing the likelihood that additional battery cells will ignite.* *- Do not use fire resistant burn bags to isolate burning lithium type batteries. Transferring a burning appliance into a burn bag may be extremely hazardous.*

END OF PROC

(fig.8) *Lithium battery fire CCOM procedure*

Lithium battery fire procedure

This procedure **(fig.8)** proposes the use of Halon to extinguish open flames, and water (or a non-alcoholic liquid) to cool the device down.

The recommendation is then to immerse the device in a suitable container (such as a waste bin, or standard galley container) to secure against thermal runaway (refer to the third step below).

Overhead bin smoke/fire procedure

Lithium battery fires may sometimes not easily be identified, and considering the specific cases when fires have actually occurred in service, the procedure for fire in the overhead compartment **(fig.9)** now considers as a base that a Lithium battery powered device may be at the origin of the fire.

Therefore the overhead bin smoke/fire procedure now covers the use of Halon and liquid to tackle the fire, and makes reference to the other two cabin crew procedures to address a Lithium battery fire.

OVERHEAD BIN SMOKE/FIRE PROCEDURE

Ident.: 09-020-00004671.0001001 / 28 JAN 14
Criteria: LR
Applicable to: ALL

Smoke/fire in overhead bins may be caused by the contents (i.e. electronic device, spare lithium battery) or electrical malfunction in the Passenger Service Unit (PSU).
The firefighter, the assistant firefighter, the communicator and the support crewmembers must conduct their tasks simultaneously.

- **When smoke is coming from an overhead bin:**

FIREFIGHTER AND ASSISTANT FIREFIGHTER
PBE..DON

FIREFIGHTER
FIRE EXTINGUISHER..TAKE

Note: *Consider the use of fire gloves.*

ASSISTANT FIREFIGHTER
WATER OR NON-ALCOHOLIC LIQUID..TAKE

Note: *Water or non-alcoholic liquid is required if the fire involves lithium battery.*

SUPPORT CREWMEMBERS
PASSENGERS..RELOCATE

COMMUNICATOR
FLIGHT CREW..NOTIFY IMMEDIATELY VIA INTERPHONE

FIREFIGHTER
OVERHEAD BIN..CHECK FOR HEAT
Using the back of the hand, feel the overhead bin to determine the temperature and presence of fire.
(*)OVERHEAD BIN..OPEN SLIGHTLY
Enough to pass the nozzle of the fire extinguisher.

CAUTION	Opening the overhead bin more than necessary can cause contamination of the cabin with smoke, and can result in smoke inhalation.

(*)FIRE EXTINGUISHER..DISCHARGE

Note: *The fire extinguisher must be discharged into the overhead bin, away from the seat, to prevent debris from contaminating the cabin.*

(*)OVERHEAD BIN..CLOSE AND LATCH

Continued on the following page

OVERHEAD BIN SMOKE/FIRE PROCEDURE (Cont'd)

FIREFIGHTING..REPEAT AS NECESSARY
(*)Repeat last three steps of the procedure, as necessary.

- **When the flames are suppressed:**

FIREFIGHTER
OVERHEAD BIN..CHECK THE SOURCE OF FIRE

Note: *The assistant firefighter must support the firefighter in the case of re-ignition by using fire extinguisher.*

- **If source of smoke/fire is coming from a visible PED and/or Spare batteries:**

FIREFIGHTER
ON PED OR SPARE LITHIUM BATTERIES..
....POUR WATER OR NON-ALCOHOLIC LIQUID
The PED or Spare lithium batteries must be cooled down by pouring water or non-alcoholic liquids.

- **If the source of smoke/fire is coming from an identified item:**

FIREFIGHTER
IDENTIFIED ITEM..TAKE OUT
ON IDENTIFIED ITEM..POUR WATER OR NON-ALCOHOLIC LIQUID
The identified item must be cooled down by pouring water or non-alcoholic liquids.

- **If the source of smoke/fire is coming from a non-identified item:**

FIREFIGHTER
OVERHEAD BIN..EMPTY WITH CAUTION

Note: *Empty the overhead bin until the source of smoke/fire is identified.*

ON IDENTIFIED ITEM..POUR WATER OR NON-ALCOHOLIC LIQUID
The identified item must be cooled down by pouring water or non-alcoholic liquids.

STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE..APPLY

END OF PROC

(fig.9) *Overhead bin smoke/ fire CCOM procedure*

STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE

Ident.: 09-020-00015206.0001001 / 28 JAN 14
Criteria: LR
Applicable to: ALL

- **When the PED or the spare battery can be safely moved:**

FIRE GLOVES..PUT ON
RECEPTACLE..TAKE
Consider the use of any suitable empty receptacle (e.g. standard unit or lavatory waste bin ...)
RECEPTACLE..FILL WITH WATER OR NON-ALCOHOLIC LIQUID
PED OR SPARE BATTERY..IMMERSE
Total immersion of the PED or the spare battery will prevent fire re-ignition.
RECEPTACLE..STORE INTO THE NEAREST LAVATORY
LAVATORY..SET AS INOPERATIVE
AFFECTED LAVATORY..MONITOR
The affected lavatory must be regularly monitored for the remainder of the flight to ensure that the device remains immersed.

END OF PROC

(fig.10) *Storage after a Lithium battery fire CCOM procedure*

Storage procedure after a Lithium battery fire

As referenced in the first step above, this procedure **(fig.10)** is called at the end of the two previous procedures.

Once the fire has been contained and the device can be safely moved, this procedure recommends to place receptacle where the burning/heating device was immersed in a lavatory and subject it to regular monitoring.

The lavatory is proposed as it contains a means of smoke detection, but is also a location that can secure the device away from the passengers and provides waterproof floor designed to receive water in case of turbulent conditions.

Flight crew procedure

More and more flying crews are taking advantage of the capabilities offered by Electronic Flight Bags (EFBs), the majority of which use Lithium batteries as a primary power source. But Lithium batteries may also enter a cockpit in the form of a flashlight, laptop, tablet, camera, mobile phone,... i.e. any Portable Electronic Devices (PEDs).

With the aim to preventing a Lithium battery fire, the key is to ensure that the EFBs and other PEDs are not exposed to abuse conditions (i.e. dropped or damaged), and if damaged, not used until confirmed serviceable. However, if the feared situation occurs, flight crew procedures have been developed on the basis of key principles: Fly, Navigate, Communicate, with appropriate task sharing.

The philosophy of the Airbus "Smoke/Fire from Lithium battery" procedure **(fig.11)** is:

- One pilot needs to continue flying the aircraft, while the second pilot will address the detected fire. If necessary, transfer control. Usually the fire fighter is the one the closest to the fire.
- Establish communication with the cabin – a Lithium battery fire should be managed as a whole crew concern – to initiate the "Storage after a Lithium battery fire" procedure.
- Secure the safety of the flight crew: the Pilot Flying should don the oxygen mask, while the pilot that will tackle the fire should don the Portable Breathing Equipment (PBE).
- Use Halon to extinguish any open flames.
- Once there are no more open flames:
  - If it is not possible to remove the burning/heating device from flight deck, pour water or non-alcoholic liquid on the device to cool it down. Be aware of possible explosion. Tests completed by Airbus have confirmed that a small quantity of water aimed at the device is sufficient to cool it and mitigate the consequences of the thermal runaway.
  - If it is possible to move the device: transfer it to the cabin and use the Cabin Crew Lithium battery procedures to secure it, by immersion in water or non-alcoholic liquid.

SMOKE/FIRE FROM LITHIUM BATTERY

If necessary, transfer control to the flight crew member seated on the opposite side of the fire

CKPT/CAB COM.. ESTABLISH
STORAGE AFTER Li BAT FIRE cabin procedure...........
.... REQUEST INITIATION

- **If there are flames:**
  CREW OXY MASK (PF)..................................USE
  SMOKE HOOD (PM).......................................USE
  HALON EXTINGUISHER.................................USE
- **If there are no flames or when flames are extinguished:**
  - **If not possible to remove device from the cockpit:**
    WATER or NON-ALCOHOLIC LIQUID.................
    ....POUR ON DEVICE
    DEVICE...MONITOR
  - **If possible to remove device from the cockpit:**
    DEVICE............................TRANSFER TO CABIN

(fig.11) *Smoke/fire from Lithium battery QRH procedure*

? DID YOU KNOW?

To know more about Lithium battery fires management in the cabin, and cabin safety issues in general, read our brochure "Getting to grips with cabin safety", available on Airbus World.

Lithium batteries have existed for more than 20 years now and are widely used in all daily applications. This technology is extremely efficient and its range of applications is constantly expanding. Whilst fortunately events involving Lithium batteries are rare, and even rarer when occurring in flight, the risk of fire still exists. The specificities of Lithium batteries need therefore to be considered in all aspects of aircraft applications and managed correctly – whether carried as cargo, or installed as equipment in the flight deck or cabin, or just as part of the passengers carry-on baggage.

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