DANGEROUS GOODS PANEL (DGP)
WORKING GROUP MEETING (DGP-WG/15)

Montreal, 27 April to 1 May 2015

Agenda Item 5: Development of mitigating measures to address risks associated with the transport of lithium batteries including measures that address recommendations from the Second International Multidisciplinary Lithium Battery Transport Coordination Meeting

5.6: Miscellaneous lithium battery issues

A RISK ASSESSMENT ON LITHIUM BATTERIES WHEN CARRIED AS CARGO

(Presented by B. Firkins)

SUMMARY

Ahead of the Second International Multi-Discipline Lithium Battery Working Group in Cologne in September 2014; a group of Australians came together to perform a risk assessment.

The outcomes of the Cologne meeting presented options in mitigating risks and contributed to the collective body of knowledge for the safe transport of dangerous goods and largely superseded the Australian body of work.

DGP-WG15-WP/4, presented by the International Federation of Airline Pilots Association (IFALPA) and the International Coordination Council for Aerospace Industry Association (ICCAIA), contains the start of a risk assessment.

In order to assist in developing the collective body of knowledge; Appendix contains the last draft of the Australian Risk Assessment. Future iterations will be brought forward where it is considered that they will contribute positively to aviation safety.

1. INTRODUCTION

1.1 Ahead of the Second International Multi-Discipline Working Group on Lithium Batteries in Cologne in September 2014; a group of Australian personnel came together to perform a risk assessment. The piece of work is not complete.

1.2 The outcomes of the Cologne meeting presented options in mitigating risks and contributed to the collective body of knowledge for the even safer transport of lithium batteries.

1.3 DGP-WG15-WP/4, presented by IFALPA and the ICCAIA, contains the start of a risk assessment but does not continue the exercise.

1.4 After the publication of DGP-WG/15-WP/4, a number of operators moved to an immediate self-imposed prohibition on UN 3480 and UN 3090.

1.5 It has transpired that many of the foreign operators who were questioned, had based their decision in response to elements of the discussion paper being circulated in the media.

1.6 Operators did not wait for the discussion of the paper at the ICAO Dangerous Goods Panel (or any other panel); and further inquiries revealed that many of those operators went against the advice of their own subject matter experts.

1.7 Of further concern was the news that many of those operators spoken with, had not undertaken a risk assessment on the likely consequences and impacts of such a prohibition.

1.8 In order to assist in continuing to develop the collective global body of knowledge; Appendix contains the last draft of the Australian Risk Assessment. The team will probably convene again in 2015. Future developments will be brought forward to the DGP and other panels where it is considered that those developments will contribute positively to aviation safety.

1.9 The personal details of the individuals involved in the exercise (in Annex C), have been removed from public versions of the document.

2. DISCUSSION

2.1 The DGP is invited to:

a) note the draft Risk Assessment contained in the Appendix;

b) encourage operators and regulators to perform risk assessments in line with the Safety Management principles that ICAO espouses;

c) continue to build upon the global body of knowledge for the safer transport of dangerous goods .

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APPENDIX

LITHIUM (METAL AND ION) BATTERIES ON PASSENGER AND CARGO AIRCRAFT

Lithium (Metal and Ion) Batteries on Passenger and Cargo Aircraft

RISK ASSESSMENT

EXECUTIVE SUMMARY

A multi-disciplinary team of experts, Australian delegates to International Panels and peak Industry representatives was brought together, ahead of an International Working Group Meeting in Cologne, Germany, in September 2014, to conduct a risk assessment exercise in respect of lithium batteries, when carried as cargo on an aircraft.

The findings were:

- risks are heightened through hidden dangerous goods, where either
  - the lithium batteries are hidden and could therefore become the source of a fire, or
  - where there is other hidden dangerous goods, which causes a fire and threatens a shipment of declared lithium batteries.
- identification that risk event triggers may lie in abnormally high storage temperatures prior to lithium batteries being accepted/loaded onto an aircraft.

The findings will shape an increasing focus on hidden and mis-declared dangerous goods as being the likely precursor to an event involving an on-board fire.

There will also need to continue the exploration of methods

- to reduce the potential, in both likelihood and impact, of an event involving lithium batteries; and,
- to increase the effectiveness and efficiency of recovery measures, should there be such an event.

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1. Introduction

There has been increasing global attention paid to Lithium batteries, both lithium metal (generally single use and non-rechargeable) and lithium ion (generally rechargeable). Significant work has been undertaken by the FAA's Fire Test Centre on examining the properties of lithium batteries when exposed to heat and/or fire. The ubiquitous presence of lithium batteries, powering devices in everyday use; and the continually evolving creation of new batteries and new chemistries, result in a fundamental questions of "What are the extant, and anticipated, risks involved with lithium batteries in the air transportation system? Where risks are unacceptable, what mitigating measures can be applied?"

2. Context

ICAO has convened the Second International Multi-Disciplinary Lithium Battery Working Group (SIMDLBWG) to meet in Cologne, Germany 9-11 Sep 2014.

Whilst the SIMDLBWG will be considering the carriage of lithium metal and lithium ion batteries as cargo; the Australian risk assessment team has considered the carriage of lithium batteries as part of aircraft equipment, as Operator's property and as provisions made for passengers and crew and their baggage. It is envisaged that the work undertaken by the Australian team will be able to be fed into other ICAO Panels and the UN Committee of Experts on Dangerous Goods (UN COE) in order to better inform and consider the interplay in Airworthiness, Flying Operations, Security, Rescue and Fire-Fighting, Safety Management Systems and Facilitation.

The objectives of the risk assessment team are to:

- Assess the safe carriage of lithium batteries in cargo/ passenger flights
- Identifying risks associated with lithium batteries as part of aircraft systems (batteries, data loggers, life rafts etc) and where necessary, to be addressed later by maintenance/ certification groups
- Identify potential mitigation options.
- Consider the risk implications of a general prohibition upon carriage of lithium batteries on aircraft
- Identify the existing controls and their adequacy/ effectiveness
- Identify the likelihood of the risks occurring

A risk assessment team was established comprised of officers from the Civil Aviation Safety Authority (CASA), the Department of Infrastructure & Regional Development (the Department), and the Australian Dangerous Goods Air Transport Council (ADGATC). The team consisted of the personnel listed in Annex C.
The assessment tool used in this exercise is the same tool used by CASA in the performance of its Risk Assessment exercises.

The preferred approach is that risks are assessed and any mitigating measures are required through an evidence-based need. Requirements for regulatory change, or which have an impost upon the aviation industry, should

only be introduced where necessary and where existing mitigation measures do not achieve an appropriate level of safety. The aviation industry is encouraged to take responsibility for safety and empowered to seek and implement higher safety standards.

3. Discussion References

- Paper titled 'A Safety Management Review of the provisions for the transportation of lithium metal batteries on passenger aircraft' (B. Firkins, ICAO Dangerous Goods Panel, Working Paper 5, April 2014).
- Invitation to the Second Meeting of International Multi-Disciplinary Lithium Battery Working Group (SIMDLBWG), including Recommendations from the first IMDLBWG.

4. Resources

Initially, tasking is for the risk assessment team to undertake reviews, consider options, analyse the related risks and identify potential mitigating strategies. The impact of the mitigating strategies will also be discussed.

Available resources are the extant resources within CASA, the Department and the Aviation industry.

5. Assumptions

The prohibition of Lithium Metal Batteries, UN 3090, as cargo on passenger aircraft, due to come into effect on 1 January 2015, will come into effect.

There is a paucity of statistical data as cargo hold fires and batteries which self combust of their own volition are exceedingly rare events. This leads to a difficulty in identifying quantitative data and therefore risk liklihoods and outcomes have to be assessed on a qualititative basis.

In considering Lithium Metal Batteries – the assumption is that they are Lithium-Manganese Dioxide; which are the predominant chemistry and which present volatile flammability concerns; rather than other chemistries which burn with a characteristic that is more in common with other permitted batteries. Furthermore, worst-case considerations have been considered with respect to "bulk" shipments of AA, AAA or CR123 size; and the anticipated lower risks presented by lithium metal coin or button-cell batteries have not been assessed.

6. Out of scope

No risks and mitigation measures are ruled "out of scope" during the risk assessment phase.

The following limitations have not been considered in this exercise; and will need to be examined as a future body of work.

- Shaping manufacturer production into producing batteries, which when exposed to a fire, are less flammable or less-explosive.
- Further refinement or sub-classification of lithium batteries by the UN Committee of Experts on Dangerous Goods.
- Aircraft systems containing lithium batteries

- Regulatory burden upon the States
- Cost benefit analysis of any of the potential mitigation measures
- Regulatory impact assessment
- The social, economic and environmental impacts of any potential mitigating measures.

7. Evaluation

The likelihood and consequence ratings were based on the risk assessment matrix contained in the risk management framework. The evaluation criteria used in this assessment are detailed in the matrix at Annex A.

The evaluations have been conducted around two events:

- lithium batteries are the source of a fire
- lithium batteries, either declared or hidden/undeclared, are on board an aircraft and are affected by fire; that is, the potential to exacerbate a fire originating from other sources.

Details regarding the risk assessment tool, the ALARP (As Low As Reasonably Practicable) Principle and a description of tolerability are contained in Annex A. Ordinarily, measures identified as “Medium Risk” and in the Yellow range of the Broadly Acceptable Region, are not usually considered for further mitigation; however, the team considered that options should be debated and presented so that low-cost, high-safety-impact mitigation measures can be identified to achieve an ALARP outcome.

The Risk Identification and Analysis Worksheet is at Annex B.

8. Findings

The procedures and measures around the classification, packaging, marking, labelling, declaration, documentation, stowage, segregation, loading and unloading of dangerous goods are already a significant risk mitigation method to ensuring that dangerous goods can be transported safely.

The most significant hazardous outcomes arise in the following events

- Where the batteries are themselves, hidden, deliberately mis-declared or undeclared and become the source of the fire. These risks are exacerbated by other factors, including bulk shipments, storage in hot environmental extremes, or damaged prior to (or during) the loading process.
- Where a bulk shipment of lithium batteries is co-located with a shipment of hidden/misdeclared dangerous goods, and that hidden/misdeclared shipment begins to burn. The risks have the potential to be further exacerbated in the event that the aircraft is not equipped with Halon as fire-suppressant, as occurs with cargo aircraft.
- Some assumptions around Security Screening equipment and changed algorithms were challenged and will require a degree of continuing engagement as to how security screening can be enhanced to achieve safety-based outcomes.

- Risks appear to be higher where the battery is in use and/or being charged. In respect of lithium batteries in aircraft components, there is a potential future body of work to examine design, manufacture and testing standards that are in excess of the current UN requirements.
- In respect of cargo operations - the team was unable to determine whether an operator is best guided to carry a shipment of declared lithium batteries in a Class C or a class E compartment. The difficulty arises due to the Black Swan event of a suppressed general-cargo hold fire in a class C compartment; raising the temperature for a declared consignment of batteries, during an EDTO flight.

9. Next Steps

Many of the identified risk mitigation measures fall into either “Preventive Measures” i.e the purpose is to prevent the potential for unsafe event actually occurring, or “Recovery Measures” i.e. the purpose is to contain the unsafe fire event to a point where the aircraft can be put on the ground and the crew and where carried, the passengers, can be safely evacuated.

The implementation of Preventive Measures is preferred to enhancing Recovery Measures; in part due to the cost imposition of carrying those recovery mechanisms on every flight, even though the likelihood of an unsafe event occurring is low.

It is proposed that the team continue and that the next body of work will be to research and consider the various Preventive and Recovery Mechanisms; particularly those with a low-cost high-safety impact.

Where Preventive or Recovery Measures have a higher cost implication; then it is proposed that further information will be sourced through additional CASA and government agencies in order to develop a cost:benefit analysis and a Regulatory Impact Analysis.

Where additional Preventive and Recovery Mechanisms cannot be introduced at the level of the aviation Operator which result in a qualitative outcome that has an positioned at an acceptable level of safety; then it will be necessary to consider expending further resources in order to determine the regulatory, social and economic impacts of a general prohibition on lithium batteries as cargo.

At this point it will be fundamentally important to conduct a more detailed quantitative global safety case for a prohibition, including a risk assessment in order to consider the potential unintended consequences of a prohibition. To introduce a prohibition. without considering the increase in batteries being either misdeclared as other permitted forms of dangerous good (such as UN 3091 and UN3481 – packed with or contained in equipment); or be completely hidden (such as dry cell or alkaline batteries) would be an abrogation of safety.

RISK ASSESSMENT

The ALARP principle

The concept of 'As Low as Reasonably Practicable' or ALARP is commonly referred to for risks with significant safety or environmental consequences and is shown in the diagram below.

The approach is to divide risks into three bands, which align with the risk ratings from the risk matrix at Annex A, as follows:

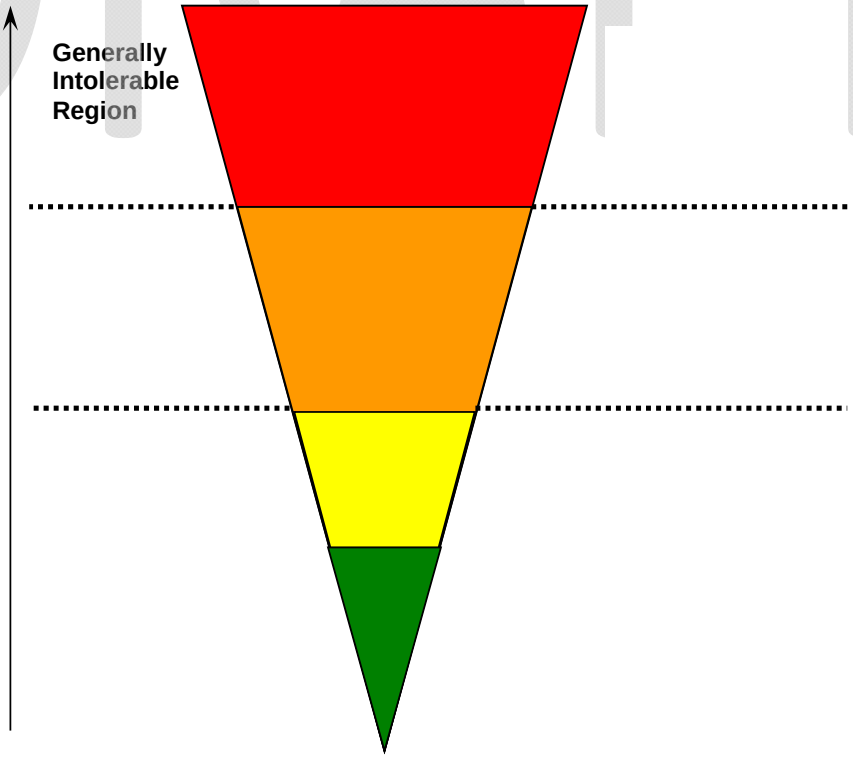
a. An upper band (risk rating > 7) where adverse risks are intolerable whatever the benefits the activity may bring and the risk reduction measures are essential whatever the cost.

b. A middle band (risk rating of 6 or 7) where costs and benefits are taken into account and opportunities balanced against potential adverse consequences.

c. A lower band (risk rating < 6) where positive or negative risks are negligible, or so small that no further risk treatment measures are needed.

Where risk is close to the intolerable level it is expected that the risk will be reduced unless the cost of reducing the risk is grossly disproportionate to the benefits gained.

Where risks are close to the negligible level then action should only be taken to reduce the risk where benefits exceed the costs of reduction.



For the purposes of this Risk Assessment and Mitigation Identification Exercise, consideration has been given to the risk ratings that were in the Broadly Acceptable Region of 4 and 5.

Furthermore, within the consequence descriptors, the determining attribute tended to be within the word-pictures of “Effect on Safety of Aircraft Operations”. Consideration was then given to the likely outcome; which tended to be shaped by bulk shipments of lithium batteries which were to the extent that the aircraft fire suppression system would be unable to cope.

There is also a paucity of statistical data on events; so likelihood descriptors were limited to qualitiative representations.

There were two likely scenarios where lithium batteries could be problematic on aircraft. Were the two events to be considered in a bow-tie analysis, then the two events would be

#1 - LITHIUM BATTERIES SELF COMBUST OR ARE THE SOURCE/ CAUSE OF THE FIRE
#2 - THERE IS AN EXTERNAL FIRE AND LITHIUM BATTERIES ARE IN PROXIMITY TO THE FIRE

Whilst each risk is addressed as a stand-alone risk, it is also recognised that where a number of risks coincide; they will have a multiplication effect.

Consequence Descriptors

	Consequences →					
	Insignificant 0	**Minor 1**	**Moderate 2**	**Major 3**	**Severe 4**	**Catastrophic 5**
People	Injuries or ailments not requiring medical treatment.	Minor injury or first aid treatment case.	Serious injury causing hospitalisation or multiple medical treatment cases.	Life threatening injury or multiple serious injuries causing hospitalisation	Multiple life threatening injuries. Aircraft occupant fatality.	Multiple fatalities. Including third party fatalities.
Operational impact on aviation activities	Operational disruption within normal operating parameters.	Operational disruption within normal operating parameters.	Notable but manageable disruption to operations or service delivery with impact to multiple and diverse areas of the business.	Significant degradation of operations or service delivery with impact to multiple and diverse areas of the business.	Severe degradation of operations or service delivery with impact to multiple and diverse areas.	Complete cessation of operations.
Reputation/Public confidence	Minor incident but no media exposure.	Several articles in the local media.	Extended negative coverage in local/state media.	Short term nationwide negative media coverage.	Extended nationwide negative media coverage.	Extended international negative media coverage and material change in public perception of company.
Effect on safety of aircraft operations	Nuisance.	Operational limitation imposed. Emergency procedures used.	Significant reduction in safety margins. Reduced capability of aircraft/crew to cope with conditions. High workload/stress on crew. Critical incident stress on crew. Injury to some occupants requiring medical treatment.	Large reduction in safety margins. Crew workload increased to point of performance decrement. Serious injury to small number of occupants causing hospitalisation. Intense critical incident stress.	Severe reduction in safety margins. Significant performance decrement for crew. Serious or fatal injury to small number of occupants. Intense critical incident stress. Large margin of chance preventing catastrophe.	Conditions preventing continued safe flight and landing. Multiple deaths with loss of aircraft.

>7: Extreme risk

– detailed treatment plan required

6,7: High risk

– needs senior management attention and treatment plan as appropriate

4,5: Medium risk

– manager level attention and monitoring as appropriate

<4: Low risk

Probability	Historical			Insignificant 0	Minor 1	Moderate 2	Major 3	Severe 4	Catastrophic 5
↑	Is expected to occur in most circumstances	Almost Certain	(5)	5	6	7	8	9	10
	Will probably occur	Likely	(4)	4	5	6	7	8	9
	Might occur at some time in the future	Possible	(3)	3	4	5	6	7	8
	Could occur but considered unlikely or doubtful	Unlikely	(2)	2	3	4	5	6	7
	May occur in exceptional circumstances	Rare	(1)	1	2	3	4	5	6
↓	Could only occur under specific conditions and extraordinary circumstances	Extremely Rare	(0)	0	1	2	3	4	5

ANNEX B

IDENTIFYING AND ANALYSING RISK WORKSHEET

Activity/Project: Lithium Batteries in aircraft

Division/Branch: **CASA and The Department**

Completed by: Risk Assessment Team

Date:

Reviewed by:

Date:

1. THE EVENTS

#1 - LITHIUM BATTERIES SELF COMBUST OR ARE THE SOURCE/ CAUSE OF THE FIRE (RISK NOS 1-13)

#2 - THERE IS AN EXTERNAL FIRE AND LITHIUM BATTERIES ARE IN PROXIMITY TO THE FIRE (RISK NOS 14-18)

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
EVENT #1 LITHIUM BATTERIES SELF COMBUST OR ARE THE SOURCE/ CAUSE OF THE FIRE ON THE AIRCRAFT									
1	Faulty battery An assumption is battery type is approved and meets UN 38.3 test standards; but either has: -Manufacturing defects; or Been Repaired or tampered with (either authorised/unauthorised) Note: faulty batteries tend to fail to hold a charge. They do not spontaneously combust during normal conditions of storage or transport	UN mandated tests and standards Manufacturing QA programs Batteries recalled due to unsafe defects are not permitted to be consigned as airfreight	2	1 Minor -	3	Y	Improved battery standards Specification on rechargeable battery's "State of charge" when transported	1	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
2	Low quality/ counterfeit or inferior battery which does not meet UN 38.3 requirements Note: Poor quality batteries tend to be the cause of the fire whilst they are being recharged or discharged or short-circuited.	Legislation in some areas QA programs (some) Threat of prosecution/ enforcement Refusal to carry by the operator unless demonstrated compliance with UN 38.3 by an accredited laboratory Consumer Safety Agencies Customs & import inspection	0	4 Severe,	4	Partially effective	Consumer education Battery Industry rating scheme Further Industry awareness of applicable battery standards e.g UN 38.3 Registration system for approved manufacturers/distributors Ready availability/access to the certificate of compliance to applicable standards Global industry code of practice Gov't or ICAO inspection/ compliance programs Potential criminal penalties Bi-lateral trade agreements	2	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
3	Damage to the battery - Dropped (known and unknown) - Crushed - Corroded - Overheated -	Design standards of the battery Packaging Shipping instructions Labelling Training/ handling procedures Identification of damaged packages and their removal from the transport chain	3	1, Minor Most crush and overheating events arise through individual items which are powered by a battery contained in equipment.	4	Partially effective	Industry education and awareness i.e. shippers and ground handlers. Reinforce message of "if damaged – remove it from the transport chain" Pre-determined length of time (i.e.4 hour hold of cargo prior to loading on aircraft – reduce likelihood of unknown damage to batteries causing a fire – also ensuring containment area is fit for purpose (does not introduce further risks such as temperature extremes). Shock sensors contained in the shipment to monitor "normal" impacts encountered in air transport; possibly with alerting indications if impacts are excessive Thermal imaging cameras to detect temperature/ thermal runaway Thermal sensors/ data loggers attached to the shipment. Improved packaging - Water packets - Gel - Fire-resistant foam pellets	1	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
4	Short circuited - Passenger items - Includes checked-in baggage (generally small, single item batteries) The hazard is that poorly prepared/packaged batteries are able to short out, generate heat and go into thermal runaway.	Packaging standards Guidance/ information Contained as intended i.e in the device Threat of prosecution/ enforcement Some security screening	3	1, Minor. Note: Where batteries short out in a passenger's baggage in the hold, then the normally anticipated quantities are such that the aircraft's fire suppression systems will extinguish the fire once the fuel in the batteries has been consumed.	4	Mostly Effective	Education and awareness for passengers to package items properly Enhanced checked-baggage security screening equipment and software for the detection of lithium batteries. Enhanced screening/ examination officer training for detection of lithium batteries and DGs. Additional standards to enforce the quantity and carriage of batteries Universal case/ container for safe carriage of spare batteries Introduce Standards for automatic protection/ isolation of terminals in batteries	2	
5	Short-circuited – declared Cargo item *Note: Most short-circuits in batteries in cargo tend to arise through not being properly packed, marked, labelled and declared.* Loose shipments/ separated i.e. small items contained in amongst other general cargo items and found in postal/ small parcel courier companies	Packaging standards Guidance/ information Contained as intended i.e in the device Threat of prosecution/ enforcement Aircraft fire detection/suppression	1	1, minor.	2	Mostly Effective	Enhanced screening/ examination officer training for detection of lithium batteries and DGs Future technologies for detection Appropriate storage of batteries Smaller sized shipments Enhance packaging standards - Airline procedures packing - Manufacturing packaging Industry education and awareness and guidance material i.e. shippers and ground	1	
	Short circuit – declared cargo item Bulk shipments		1	5, Catastrophic	6				

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
	Short circuit – declared cargo item Large mass batteries (cars etc)		1	4, Severe	5		handlers ULDs and fire containment/resistance covers using improved materials for fire containment ULD with additional fire detection and suppression capability for general cargo ULD with additional fire detection and suppression capability		

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
6	Undeclared consignment of lithium batteries (doesn't meet UN specification packing instructions, not labelled, not inspected, handled, stowed and secured as per a declared DG consignment). The hazard is that because the batteries are undeclared, they are completely invisible to the operator and will not receive the same level of care and handling that a declared DG shipment does. They are therefore more susceptible to triggers caused by overheating, damage and short-circuit.	Training and awareness Threat of Prosecution/ Regulatory investigations & Enforcement Public Education Security screening (considered but note limited adequacy)	4	4 – Severe Depending on the size, quantity and chemistry of the shipment the outcome could be catastrophic.	8	N	enhanced security screening algorithms/ technology More targeted education and awareness for passengers/ manufacturers to package items properly Enhanced education for screeners/ handlers to spot undeclared DGs Identification of improvement of standards to mitigate the risk ULD with additional fire detection and suppression capability for general cargo ULD with additional fire detection and suppression capability Education to operators "know your customers" Regulated agents/ freight forwarder to "know your shipper" and build upon "secure supply chain". Aligning/rectifying public perception of aviation security and aviation safety. (the public tends to view the two as complementary and synonymous; and is not generally consistent with the practises in the aviation industry.	2	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
7	Intentional Batteries in-use – device switched on and/or charging in cabin i.e, - Tablets - Laptops - PEDs etc - Medical devices Note: Higher likelihood than Risk No. 8 due to charging scenario.	Design standards (normally a small sized battery) Contained in an appropriate device and in the passenger carry-on bag Training / emergency procedures for the cabin.	3	Minor 1	4	Y	Further travelling public education and awareness. Limitation of current draw within the aircraft/ charging points	2	
8	Intentional Batteries in-use – device switched on in cargo holds i.e , - Freight/valuable cargo - tracking GPS device; RFIDs etc - data loggers (temperature, pressure, impact etc) - Bag tags - Powered systems for temperature (freezer units) or water aeration (aquatic animals)	Design standards (normally a small sized battery) Contained in a device and in the passenger bag / cargo container Device designed for the environment Maintenance programs and training for servicing and preparation of larger systems	1	1, Minor	2	Y		1	
9	Unintentional activation: Device turns on due to knocks / malfunction etc - wheelchairs	Security screening Device packaging Guidance/ education Profiling passengers by ground staff	3	2 Moderate	5	Partially effective	More education and awareness Promoting applicable immobilising devices Improved standards for containment/ transport of wheelchair batteries Standards for automatic protection/ isolation	2	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
	- *normal batteries in toys, tools etc		4	1	5		of equipment Isolation/ segregation ULD with additional fire detection and suppression capability for general cargo		
10	Batteries within the aircraft systems	Battery manufacturing standards Aircraft design standards Some fire protection/ detection/ suppression systems High manufacturing standards and QA Mandatory continuing airworthiness action	2	3, Major	5	Mostly effective	Higher testing standards for batteries forming part of aircraft equipment including assembled components.	1	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
11	Environment pre-loading/ pre-departure: - extreme temperature or large change in temperature. - extreme pressure or large change in pressure - Moisture (high humidity or rain causing a means to short circuit between batteries)	Shipping instructions Packaging standards Training/ handling procedures Inspection, identification and potential removal from transport chain Regulatory inspections	3	4 Severe	7	Partially effective	More guidance and education to operators Not storing declared shipments of lithium batteries in direct sunlight or hot environments for extended period of time Improved packaging standards Improved storage facilities for applicable locations i.e extreme heat/ cold Data loggers (passive or with active alarms) accompanying the shipment. Temperature controlled ULDs Additional UN tests outside of current temperature ranges	1	
12	Damage to the device containing lithium battery i.e. other unsecured cargo shifting and hitting the dangerous goods resulting in either the battery being damaged and causing the fire; or the device being damaged and in the ensuing short-circuit overheating to the point of starting a fire.	Packaging/ labelling Training & education	2	1 Minor	3	Mostly effective	More education and training	1	
13	Spontaneous combustion i.e. batteries are compliant with UN 38.3 tests and combustion not arising from use, misuse, abuse, tampering, forced discharge, charging, removal of protective devices, crushing, heating etc.	Design standards for the batteries Production control QA	0	4 Severe	4	Y			
EVENT #2 - THERE IS A FIRE IN THE CARGO HOLD AND LITHIUM BATTERIES (BULK) ARE IN PROXIMITY TO THE FIRE									

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
14	Fire initiated by aircraft system progressing to a cargo fire - e.g Cargo too close to aircraft lighting	Design standards for both aircraft and battery Continuing airworthiness Detection systems for fire/ smoke Detection systems for failure in aircraft system Emergency procedures and training	1	3 Major If the fire from a malfunctioning aircraft system, takes sufficient hold to penetrate the cargo liner and threaten a consignment of lithium batteries; then the aircraft is probably already lost.	4	Y	Improved ULD standards Improved cargo liner standards Improved fire detection systems Increased continuing airworthiness inspections	0	
15	Fire initiated by declared dangerous goods cargo	UN Classification of dangerous goods Packaging standards and instructions Packing Groups – limiting quantities that are of a higher risk Marking and labelling Inspection Stowed and secured Segregation of incompatible DGs Notification to flight crew Emergency Procedures	0	4 Severe Dangerous Goods incidents and occurrences arise from hidden and mis-declared DG.	4	Mostly effective	Further segregation of class 9 lithium batteries from other declared liquid DGs ULD with additional fire detection and suppression capability Improved packaging - Water packets - Gel - Fire-resistant foam pellets Improved fire suppression standards - Fire resistant ULDs	0	

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
16	Fire initiated by undeclared dangerous goods cargo (Note Risk No.6 deals with the hazard of a fire starting with undeclared lithium batteries; this hazard is in respect of a fire arising from another consignment of undeclared DG and spreading to a declared shipment of lithium batteries).	Threat of enforcement and prosecution Inspection Limited security and screening	2	Moderate 4	6	N	ULD with additional fire detection and suppression capability for general cargo Further segregation of class 9 DGs. ULD with additional fire detection and suppression capability Improved packaging and fire suppression standards - Water packets - Gel - Foam pellets - Fire resistant canisters - Targeted education program on non-declared goods	1	
17	Fire initiated by non-dangerous goods cargo - Vibration causes friction – wood dunnage - smouldering etc - Escaped Animals chewing aircraft wiring and causing a short/fire.	Inspection Securing cargo adequately Training and procedures Aircraft fire detection and suppression Standards of transporting live animals Procedures for reporting escaped animals etc	1	1, Minor	2	Y			

Risk No.	The Risk What can happen and How it can happen leading to the event	Existing controls	Likelihood	Current Likely Consequences	Risk outcome	Adequacy of Controls Yes/Mostly/Partly/No	Additional treatment / control option to reduce the likelihood further	Target Likelihood	
18	Intentional explosive or criminal act/ terrorist The hazard is whether an intention to do harm would be achieved through devising a fire/explosion which would spread to a co-loaded consignment of a bulk shipment of lithium batteries, turning a survivable incident into an unsurvivable one.	Security and screening processes Training, passenger profiling Aircraft design standards Pre-flight inspection Security within the Cargo supply chain	0	5 Catastrophic The likelihood is that the aircraft would already be severely damaged from an explosion	5	Y			

2. CONSEQUENCES OF THE FIRE REGARDLESS OF HOW THE FIRE STARTED

APPLYING THE RISK ANALYSIS FRAMEWORK – RISK OUTCOMES IN THE "GENERALLY INTOLERABLE" AND "ALARP OR TOLERABLE" REGIONS

- **THE TRIGGERS FOR RISKS 6 AND 16 ARE HEIGHTENED THROUGH HIDDEN DANGEROUS GOODS, WHERE EITHER THE LITHIUM BATTERIES ARE HIDDEN AND COULD THEREFORE BECOME THE SOURCE OF A FIRE, OR WHERE THERE IS OTHER HIDDEN DANGEROUS GOODS, WHICH CAUSES A FIRE AND THREATENS A SHIPMENT OF DECLARED LITHIUM BATTERIES.**
- **RISK 11 HAS ITS TRIGGERS IN ABNORMALLY HIGH STORAGE TEMPERATURES PRIOR TO BEING ACCEPTED/LOADED ONTO THE AIRCRAFT**

Risk No.	The Consequence from an event happening	Description and Adequacy of Existing Controls	Controls adequate? Y/N	Additional treatment / control option to reduce the consequences		
6, 11 & 16	Catastrophic - Cargo aircraft loss if fire takes hold from a source and spreads to a bulk shipment of declared lithium metal batteries (UN3090) or lithium ion (UN3480) in Class E cargo compartment *reconsider class of aircraft/ cargo compartment and controls	Procedure with fire in a Class E compartment is to climb to 22,000', depressurise, one crew member to attempt to fight fire. Land as soon as possible.	N	Improved security screening algorithms. Retrofit cargo aircraft to increase number of smoke/fire detectors ULD with additional fire detection and suppression capability for general cargo ULDs with improved fire-resistant capabilities Fire Containment Covers. Operator procedure of assigning declared lithium battery shipments to a Class C compartment. Not co-loading lithium batteries with potentially incompatible DG shipments (classes 1, 3, 4 and 8) Fire containment covers "Assured vision" retrofits for flight deck visibility of instruments and windscreen. Procedures for expedited ditching/forced landing.		

	Major - Passenger aircraft threatened if bulk shipment of declared lithium ion batteries (UN3480) are exposed to heat/fire.	Cargo hold fires are very rare – usually false alarms or caused by short in Aircraft systems. Cargo Holds equipped with fire detection and suppression systems.	N	Not co-loading UN 3840 with potentially incompatible DG shipments (classes 1, 3, 4 and 8) Operator education for pilots to respond immediately to fire indications		
	Catastrophic – cargo or passenger aircraft loss if bulk shipment of lithium metal batteries (UN3090) are hidden or misdeclared as Lithium Ion (UN3480), Nickel Metal Hydride or other dry-cell battery; and, are subjected to rough handling, and/or high temperatures prior to/during loading.	Current security screening equipment does not different between battery types.	N	Improved security screening algorithms/ technology Retrofitting cargo bays to exceed Class E certification standards.		

Participant	**Employer and Functional Role(s)**
	CASA – Risk & Quality Assurance
	CASA - Manager Governance Systems
	The Department – Aviation Safety, Policy and Governance
	CASA – Dangerous Good Inspector, Operations Division and ICAO Dangerous Goods Panel Member
	The Department – Australian Representative to the UN Committee of Experts on the Transport of Dangerous Goods
	Office of transport Security – Assistant Director, Regulatory Management, Transport Security Operations and ex- Member of the ICAO Dangerous Goods Panel
	Office of Transport Security
	CASA – Senior Standards Officer, Certification, Standards Division and ICAO Airworthiness Panel Member
	CASA – Large Aircraft Flying operations, Standards Division and ICAO Flying Operations Panel Member
	CASA – Senior Engineer, Standards Division
	CASA – Section Head, Safety Promotion Delivery, Safety Promotion and Education Division
	CASA – Communications Delivery, Safety Promotion and Education Division
	CASA – Safety Analyst, Safety Systems Office, Office of the Director of Aviation Safety
	CASA – Safety Performance Management Specialist, Safety Systems Office, Office of the Director of Aviation Safety
	ADGATC – Regulatory Advisor and Manager Dangerous Goods Safety Standards and Compliance, Qantas and IATA Dangerous Goods Board member.
	ADGATC – Australian Air Freight advisor and Manager Qantas Freight Enterprises.